ANNUAL CONVENTION, SEPTEMBER 14, 1904.
Festival Hall, Louisiana Purchase Exposition, St. Louis, Mo.

Entered as matter of the second class at the New York, N. Y. Post Office, Nov. 20th, 1890.

VOLUME XXI.
NUMBER 7.

SEPTEMBER, 1904.

Annual Subscription, $5.00
Single Copies 50

TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

ELECTRICAL ENGINEERS.

CONTENTS.

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PUBLISHED MONTHLY (EXCEPTING JULY AND AUGUST) BY THE INSTITUTE, UNDER THE SUPERVISION OF THE EDITING COMMITTEE.

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OF THE

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Vol. XXI. SEPTEMBER, 1904. No. 7

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R. N. WILLIAMS.
H. C. WIRT.

ST. LOUIS.

W. V. N. POWELSON, Chairman
Union Electric Light & Power Co., St. Louis.

W. A. BAEHR
JOHN I. BEGGS
MURRAY CARLETON
E. G. COWDERY
S. M. DODD
G. F. DURANT
W. E. GOLDSBOROUGH
H. H. HUMPHREY
S. M. KENNARD
A. S. LANGSDORF
W. A. LAYMAN
ROBERT McCULLOCH
W. F. NOELKER
G. PANTALEONI
H. L. REBER
O. D. ROSENTHAL
ROGER SCUDDER
J. E. SMITH
E. J. SPENCER
GERARD SWOPE
J. S. WALSH

WASHINGTON, D. C.

GEN. GEORGE H. HARRIES, Chairman,
Wash. Ry. & Elec. Co.,
14th and East Capitol Sts., Washington, D. C.

ALEX. GRAHAM BELL
F. H. BETHELL
PHILANDER BETTS
JOHN BIDDLE
GEO. T. DUNLOP
R. A. PESSENDEN
BERNARD R. GREEN
WILLIS L. MOORE
CHAS. W. NEEDHAM
SAMUEL REBER
F. B. ROSA
L. E. SINCLAIR
S. W. STRATTON
O. H. TITTMAN
CHAS. D. WOLCOTT
F. A. WOLFF

ANNUAL CONVENTION, SEPTEMBER 14, 1904.
ST. LOUIS, MO.

On Wednesday, September 14, 1904, at 10 o'clock a. m., the Annual Convention of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS will be formally opened at Festival Hall in the grounds of the Louisiana Purchase Exposition. The President of the INSTITUTE, Mr. Bion J. Arnold, will then deliver the annual address. Immediately afterward will follow a topical discussion between the Institution of Electrical Engineers of Great Britain and the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, on the subject, "Different Methods and Systems of Using the Alternating Current in Electric Railway Motors." The INSTITUTE will be represented by Messrs. Arnold, Lamme, and Steinmetz.

PLACE OF MEETING.
FESTIVAL HALL, LOUISIANA PURCHASE EXPOSITION,
ST. LOUIS, MO.

NEXT REGULAR INSTITUTE MEETING,
OCTOBER 28, 1904.

The subject, titles of papers, and names of authors will be announced in the October TRANSACTIONS.

PLACE OF MEETING.
CHEMISTS' CLUB.
108 West 55th St., New York.

APPLICATIONS FOR ELECTION.

Applications have been received by the Secretary from the following candidates for election to the INSTITUTE as Associates and will be considered by the Board of Directors at a future meeting.

Any Member of Associate objecting to the election of any of these candidates should so inform the Secretary before October 28, 1904.

4064 Frederick S. Gould,	Ashville, N. C.
4065 George C. Towle,	Mattoon, Ill.
4066 Ulysses S. Bell,	Atlanta, Ga.
4067 Paul W. Ripple,	East Pittsburg, Pa.

4068	C. Wellington Koiner,	Oneida, N. Y.
4069	Albert Wilmow,	Manilla, P. I.
4070	Edward J. Barton,	Panama, R. de P.
4071	John M. Donaldson,	Rugby, Eng.
4072	Sven R. Bergman,	W. Lynn, Mass.
4073	George R. Milford,	Fern, Cal.
4074	George E. Caseo,	Syracuse, N. Y.
4075	Frank R. Brosius,	Columbus, O.
4076	Arthur O. Austin,	Stockton, Cal.
4077	Herman B. Waters,	Canyon Ferry, Mont.
4078	Albert Spies,	Jersey City, N. J.
4079	Wait R. Loveless,	Lynn, Mass.
4080	Eugene F. Enslen, Jr.,	Birmingham, Ala.
4081	Ross St. J. McClellan,	Kent, Wash.
4082	Albert S. Crane,	Chicago, Ill.
4083	Francis Raymond, 3d,	Chicago, Ill.
4084	Raymond Whiteley,	London, Eng.
4085	Charles W. Davis,	Dallas, Texas.
4086	Eugene Carpenter,	Newton, Mass.
4087	Peter C. McNulty, Jr.,	Wilkinsburg, Pa.
4088	Emil Gunter,	Schenectady, N. Y.
4089	Elmer Gould Eberhardt,	Newark, N. J.
4090	Oluf G. Peterson,	Sterns, Ky.
4091	Raymond H. Harper,	Fort Wayne, Ind.
4092	Lauren D. Nordstrum,	W. Lafayette, Ind.
4093	Francis W. Hild,	Chicago, Ill.
4094	Virgil Hayden,	Buffalo, N. Y.
4095	George L. Barton,	Boston, Mass.
4096	Walter T. Goddard,	Victor, N. Y.
4097	Harold McGeorge,	Cleveland, O.
4098	Arthur J. Quigley,	New York City.
4099	William J. Hoar,	East Orange, N. J.
4100	Lee H. Kidder,	Mexico City, Mex.
4101	James W. Harris,	Manchester, Eng.
4102	Walter S. Kelley,	Providence, R. I.
4103	Harold Osborne,	St. Louis, Mo.
4014	William E. Reed,	E. Pittsburg, Pa.
4105	Anton R. Beaujon,	West Palm Beach, Fla.
4106	William A. Ferguson,	Mexico City, Mex.
4107	John A. Clay,	Burke, Idaho.

Total, 44.

THE INTERNATIONAL ELECTRICAL CONGRESS AT ST. LOUIS.

The International Electrical Congress of St. Louis will assemble in the Music Hall of the Coliseum at Olive and 13th Streets, St. Louis, Mo. at 9.30 a. m. on Monday, 12th of September, 1904. After the opening ceremonies the Congress will divide into eight sections, which will assemble in appointed rooms of the same building. The section meetings will be held each morning in the Coliseum Building on Tuesday, Wednesday, Thursday, and Friday of the same week.

The AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS will coöperate with the Congress by holding joint sessions with specific sections of the Congress on different days. These joint meetings may also be participated in by other coöperating bodies, according to a programme the details of which have not yet been completed.

Members and Associates of the INSTITUTE will be entitled to free admission by their badges to the joint meeting of each day, with the particular Congress Section only. At these joint meetings, the Chairmanship will be divided between the INSTITUTE officers and the Congress Section officers, and the proceedings will be those of the Congress and of the INSTITUTE jointly.

Up to the 1st of August about 1915 persons had signified their desire to become members of the Congress. Of these, 1562 were residents of North America, exclusive of Mexico. About 740 were members of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Membership in the Congress entitles the holder to admission to all sectional and joint meetings of the Congress, to participation in these meetings, and to receive subsequently a copy of the Transactions of the Congress. Since over 150 specially-invited papers have been promised to the Congress, it is expected that the Congress Transactions will attain either two or three octavo volumes of valuable papers and discussions. All Members and Associates of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS are entitled to become Members of the Congress, on application. The subscription fee for Congress membership is $5.00, which may be forwarded to the Treasurer of the Congress, W. D. Weaver, 114 Liberty St., New York City. or to the Congress General Secretary, Doctor A. E. Kennelly, Harvard University, Cambridge, Mass. Certificates of Membership will be issued in return for such subscriptions.

Although the Congress Membership Fee is $5.00, it is the intention to make the price of the Congress Transactions to libraries and other institutions not entitled to membership, $10.00 per set.

The Delegates of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS to the Congress are R. D. Mershon, Professor M. I. Pupin, and Doctor C. P. Steinmetz. The papers offered by these Delegates will be published as papers offered by the INSTITUTE in the Transactions of the Congress. These papers are as follows:

"The Maximum Distance to which Power can be Economically Transmitted," Ralph D. Mershon.

"Electrical Impulses and Multiple Oscillators," by Professor M. I. Pupin.

"The Theory of the Single-Phase Motor," by Doctor C. P. Steinmetz.

It has been arranged that other papers already promised to the Congress by Members of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS may also be offered on behalf of the INSTITUTE, with the consent of their authors. These papers have not yet been selected.

In addition to the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS the following national American bodies have promised to coöperate in the Congress by holding simultaneous conventions and joint sessions:

The American Electrochemical Society.

The American Physical Society.

The International Association of Municipal Electricians.

The American Electrotherapeutic Association.

The following American electrotechnical bodies have arranged to coöperate by sending delegates to read papers, without holding simultaneous conventions, or joint sessions:

National Electric Light Association.

Association of Edison Illuminating Companies.

The following foreign electrotechnical Associations have promised to coöperate by sending Delegates to the Congress:

The Societe Internationale des Electricens.

The Schweizerischer Electrotechnischer Verein.

It is expected that the Institution of Electrical Engineers of Great Britain, and the Elektrotechnischer Verein, of Berlin, will also coöperate by sending delegates. It is hoped that other foreign electrical societies will also coöperate.

It is hoped that all members of the INSTITUTE OF ELECTRICAL ENGINEERS visiting St. Louis in September will aid by their presence and membership in making this Fifth International Electrical Congress a success and a credit to American electrical science and industries.

ADVANCE COPIES INTERNATIONAL ENGINEERING CONGRESS PAPERS.

The International Engineering Congress, to be held at St. Louis, October 3 to 8, 1904, is being organized under the auspices of the American Society of Civil Engineers. Many of the papers to be presented will be of interest to electrical engineers. Among the papers are the following:

Turbines and Water Wheels, by Professor GARDNER S. WILLIAMS, Ithaca, N. Y.

Railroad Terminals, by ELMER L. CORTHELL, New York City.

Underground Railways, by WILLIAM BARCLAY PARSONS, New York.

Locomotives and Other Rolling Stock, by GEORGE GIBBS, New York.

Live Loads for Railroad Bridges, by HENRY W. HODGE, New York.

The Substitution of Electricity for Steam as a Motive Power, by JAMES G. WHITE, New York.

Passenger Elevators, by THOMAS E. BROWN, New York.

Pumping Machinery, by IRVING H. REYNOLDS, Youngstown, O.

Electrical Power—Generating Stations and Transmission, by L. B. STILLWELL, New York.

Steam Turbines, by FRANCIS HODGKINSON, Pittsburg.

Engineering Education, by Professor ROBERT FLETCHER, Hanover, N. H., Professor CALVIN M. WOODWARD, St. Louis, Mo., W. CAWTHORNE UNWIN, F. R. S., London, Eng.

Those who desire advance copies of the above papers are requested to send their names to Chas. Warren Hunt, *Secretary*, 220 West 57th St., New York.

Members receiving them may contribute discussions under such regulations as may be hereafter issued. The papers will be distributed as soon as printed. This Congress should not be confounded with the Fifth International Electrical Congress to be held at St. Louis, September 12–17.

UNIVERSITY OF ARKANSAS BRANCH.

Organized March 25, 1904.

W. N. Gladson, *Chairman.* W. A. Treadway, *Secretary.*

PLACE AND TIME OF MEETING.

Electrical Engineering Lecture Room, University of Arkansas, on the first and third Tuesdays of every month.

A meeting of this Branch was held April 19, 1904, 12 members and visitors attending. The INSTITUTE papers relative to High-pressure Transmission matters presented at the 185th meeting March 25, 1904, were read and discussed.

ARMOUR INSTITUTE OF TECHNOLOGY.

Organized February 26, 1904.

C. E. Freeman, *Chairman.*

No report has been received from this Branch.

ATLANTA BRANCH.

Organized January 19, 1904.

A. M. Schoen, *Chairman.* W. R. Collier, *Secretary and Treas.*

Managers.

G. J. Yundt, H. A. Coles, A. H. Ford, R. R. Flaxton.

PLACE OF MEETING.

Carnegie Library.

A meeting of this Branch was held May 13, 1904, 15 members and visitors attending. An original paper by A. M. Schoen entitled "The Installation of High-Voltage Motors," was presented and then discussed by Messrs, Schoen, Wotton, Wills, Layton, Coles, Balsey, Redding, and Collins.

A second meeting of this Branch was held on June 3, 11 members and visitors attending. This meeting was devoted to the business of the Branch. The officers named above were elected to serve during the ensuing year.

BOSTON BRANCH.

Organized February 13, 1903.

C. L. Edgar, *Chairman.* C. B. Burleigh, *Secretary.*

Executive Committee.

A. E. Kennelly, Louis Duncan, J. I. Ayer, Richard Fleming, Russell Robb, B. H. Clingerman, Robert Palmer.

PLACE AND TIME OF MEETING.

The Boston Branch meets at the Lowell Building, Massachusetts Institute of Technology, on the first Wednesday of every month.

A meeting of this Branch was held May 4, 1904, 125 members and visitors attending. An original paper entitled "The Steam-Turbo Generator Station of the Edison Illuminating Company of Boston," by I. E. Moultrop, was read and then discussed by Messrs. Edgar, Woodward, Rice, Perry, and Ayers. The paper was illustrated with lantern-slides.

CHICAGO BRANCH.

Organized 1893.

George A. Damon, *Chairman.* Peter Junkersfeld, *Secretary.*

Executive Committee.

George A. Damon, James Lyman, H. H. Wait,
P. B. Woodworth, K. B. Miller, J. R. Cravath,
T. P. Gaylord, Peter Junkersfeld.

PLACE OF MEETING.

Rooms of the Western Society of Engineers, Monadnock Building.

A meeting of this Branch was held April 26, 1904., 80 members and visitors attending. A preliminary announcement was made of the INSTITUTE meeting at Chicago, June 21–22, 1904, this meeting to be under the direction of the High-Tension Transmission Committee, assisted by the Chicago Branch.

The papers by Messrs. Eglin and Lukes, presented at the 182d meeting, December 18, 1903, were abstracted by Mr. Lukes and discussed by Messrs. Gear and Warner. Professor Ryan's paper, presented at the 184th meeting, February 26, 1904, was abstracted by John D. Nies of the Lewis Institute, and discussed by C. E. Freeman of the Armour Institute. Guido Semenza's paper, also presented at the 184th meeting, was abstracted by W. A. Blanck, and discussed by Messrs. Carlton and Lukes.

A description of the Tower System of Line Construction used by the Guanajuato Power and Electric Company, Mexico, was presented by L. A. Sanford.

CINCINNATI BRANCH.

Organized December 17, 1902.

B. A. Behrend, *Chairman.* J. H. Hallberg, *Vice-chairman.*
Louis E. Bogen, *Secretary.*

PLACE OF MEETING.

Bullock Electric Mfg. Co., Norwood, Ohio.

No recent report has been received from this Branch.

COLUMBUS BRANCH.

Organized December 20, 1903.

L. G. White, *Chairman.* M. C. Hull, *Secretary.*

Board of Managers.

L. G. White, Mark Simonton, F. L. Sessions,
M. S. Browne, Perry Okey.

PLACE AND TIME OF MEETING.

Meets at 142 East Gay St., Columbus, on the second and fourth Mondays from October to April, and the second Monday in April, May, and June.

A meeting of this Branch was held April 11, 18 members and visitors attending. At this meeting a committee was appointed to obtain new and permanent quarters. An original paper entitled "Police and Fire-Alarm Signaling Systems," was presented by R. H. Allmsworth.

Another meeting was held May 16, 1904, at the Engineers' Club, 19 members and visitors attending. The matter of obtaining permanent quarters at the Engineers' Club under satisfactory arrangements was discussed at length with the officers of the Club.

On June 13 the annual meeting of this Branch was held, with an attendance of 20. The following officers were elected:

L. G. White, *Chairman.*

M. C. Hull, *Secretary and Treasurer.*

CORNELL UNIVERSITY BRANCH.

Organized October 15, 1902.

Harris J. Ryan, *Chairman.* George S. Macomber, *Secretary.*

PLACE AND TIME OF MEETING.

Sibley College, Cornell University, on the second and fourth Tuesdays of every month.

No recent report has been received from this Branch.

DENVER BRANCH.

Organized December 8, 1902.

Henry L. Doherty, *Chairman*, J. W. Stearns, *1st Vice-chairman*.
H. R. Webber, *2d Vice-chairman*. A. M. Ballou, *Treasurer*.
E. Y. Sayer, *Secretary*.

PLACE OF MEETING.

Assembly Hall of the Denver Gas and Electric Co., 17th and Tremont Streets.

No recent report has been received from this Branch.

UNIVERSITY OF ILLINOIS BRANCH.

Organized November 25, 1902.

W. H. Williams, *Chairman*. Morgan Brooks, *Secretary*.

PLACE OF MEETING.

Electrical Engineering Building, University of Illinois.

No recent report has been received from this Branch.

IOWA STATE COLLEGE BRANCH.

Organized April 15, 1903.

L. B. Spinney, *Chairman*. A. R. Horn, *Vice-chairman*.
B. S. Lanphear, *Secretary*. H. M. Smith, *Treasurer*.

Executive Committee.

G. W. Bissell, W. R. Haselton, F. Roy,
W. Schwarting, M. P. Cleghorn.

PLACE AND TIME OF MEETING.

Engineering Hall of the Iowa State College on the first Wednesday of every month.

A meeting of the Executive Committee of this Branch was held April 12, 1904; at this meeting amendments to the Branch Constitution were adopted by unanimous vote.

Another meeting was held April 13, 1904, 49 members and visitors attending. The following original papers were presented and discussed:

"Electric Lighting vs. Gas Lighting," by H. W. Dow.

"Modern Sub-station Practice in Electric Railway Work," by B. S. Lanphear.

Another meeting of this Branch was held April 23, 40 members and visitors attending. J. C. Horning of the class of '99,

presented a paper entitled "Central Station Heating in Connection with Electric Light Plants." Mr. Horning described the earlier systems of steam and hot water heating, as well as those in general use at the present time.

Another meeting was held May 4, 21 members and visitors attending. At this meeting the papers presented at the 186th meeting of the INSTITUTE were read and then discussed by Messrs. Sumner, Bissell, Spinney, Schooley, Read, and Hoffman.

Another meeting of this Branch was held May 18, 1904, 168 members and visitors attending. G. McFarland, Superintendent of the Iowa Telephone Company, presented a paper entitled "Modern Telephone Engineering." The paper was illustrated with lantern-slides, line construction, aerial wires, aerial cable construction, underground cable, cable entering exchange, and cable runs in exchange, mail and intermediate distributing frames, and exchange equipment, were illustrated and described in detail. Mr. McFarland also took up the subjects of traffic and service tests.

The last meeting of this Branch for the college year 1903–4 was held May 25, 1904, 38 members and visitors attending. The officers named above were elected for the next college year:

The Chairman and Secretary are also members of the Executive Committee.

The papers presented at the 187th meeting of the INSTITUTE were abstracted and discussed. B. S. Lanphear presented a paper describing a new direct-current dynamo, built from his designs by the Iowa State College students in the college machine shop. It is a direct-current machine of the stationery armature type, having no wire, no insulation, no brushes, no commutator nor collector rings. It is to be used with a millivoltmeter as a tachometer.

LEHIGH UNIVERSITY BRANCH.

Organized October 15, 1902.

W. S. Franklin, *Chairman*. William Esty, *Secretary*.

EXECUTIVE COMMITTEE.

W. S. Franklin,	William Esty,	C. L. Orth,
J. L. Beaver,	B. A. Cornwell,	S. S. Seyfert.

PLACE AND TIME OF MEETING.

This Branch meets with the Lehigh University Electrical Engineering Society at the Physical Laboratory, Lehigh Uni-

versity, on the third Wednesday of every month, and on every Monday from September to June. At these meetings the regular INSTITUTE papers, supplemented by special papers based on articles from the current technical journals, are presented and discussed.

A meeting of the Lehigh University Branch was held March 23 at the residence of President T. M. Drown. A chalk talk on the Block Signal System of the Lehigh Valley R.R. was given by H. S. Balliet, Assistant Engineer of Signals, L. V. R.R. A paper on the Electrical Thawing of Frozen Water Pipes was presented by P. Cloke.

UNIVERSITY OF MICHIGAN.

Organized March 25, 1904.

H. S. Carhart, *Chairman*. Geo. W. Patterson, Jr., *Secretary*

No report has been received from this Branch.

MINNESOTA BRANCH.

Organized April 7, 1902.

George D. Shepardson, *Chairman*. Edward P. Burch, *Secretary*.

PLACE AND TIME OF MEETING.

This Branch meets at the Electrical Building, State University, one week later than the New York meeting.

The last reported meeting of this Branch was held May 6, 1904. The subject of the meeting was "The Design of Alternators."

UNIVERSITY OF MISSOURI BRANCH.

Organized January 10, 1903.

H. B. Shaw, *Chairman*. Wray E. Dudley, *Secretary*.

EXECUTIVE COMMITTEE.

H. B. Shaw, J. L. Woodress, L. C. Nicholson, J. E. Buckham.

PLACE AND TIME OF MEETING.

This Branch meets at the Engineering Building, State University, on the second Saturday following the New York meeting.

A meeting of this Branch was held on April 9, 1904. The INSTITUTE papers relative to High-Pressure Transmission mat-

ters, presented at the 185th meeting, were read and discussed.

The last meeting of this Branch for the school year, 1903–04, was held May 7, 1904. Wray E. Dudley was elected Secretary for the next school year. At this meeting the INSTITUTE papers presented at the 186th meeting were read and discussed.

OHIO STATE UNIVERSITY BRANCH.

Organized December 20, 1902.

W. R. Work, *Chairman*. S. B. Williams, *Secretary-Treasurer*.

Vice-presidents.

F. M. Craft, H. L. Hope, O. F. Letz.

PLACE OF MEETING.

Electrical Engineering Lecture Room, Ohio State University.

A meeting of this Branch was held April 13, 1904, when the officers printed above were elected for the ensuing college year:

An abstract of the paper by G. A. Damon, entitled "Opportunities in the Electrical Business," read before the Western Society of Engineers at Chicago, was presented and discussed.

PENNSYLVANIA STATE COLLEGE BRANCH.

Organized December 20, 1902.

John Price Jackson, *Chairman*. A. R. Dennington, *Secretary*.

PLACE AND TIME OF MEETING.

This Branch meets at the Electrical Engineering School on every Wednesday from January to June.

At these meetings the regular INSTITUTE papers, supplemented by important and interesting technical magazine articles, are presented and discussed.

A meeting of this Branch was held April 13, 1904, 25 members and visitors attending. The following officers of the Electrical Engineering Society were elected to serve for the balance of the college year:

W. E. Ketchum, *President*; P. O. Noble, *Vice-president*; H. L. Frederick, *Secretary*; H. E. Blank, *Treasurer*.

Another meeting was held April 20, 1904, 40 members and visitors attending. A paper entitled, "Drying Out High-Tension Transformers," by J. C. Peck, was abstracted by P. J. Morrissey; and a paper entitled, "The First Electric Railroad in America," by E. M. Bentley, was abstracted by J. H.

Lytle. These papers were discussed by Professor J. P. Jackson and others. A paper on the Electrical Exhibits of the Louisiana Purchase Exposition was read by W. E. Ketcham.

The last reported meeting of this Branch was held April 27, 1904, 23 members and visitors attending. The INSTITUTE paper entitled "The Relative Fire-Risk of Oil and Air-Blast Transformers," by E. W. Rice, Jr., and a paper on the Cooper-Hewitt Mercury Vapor Lamp, were read and discussed.

PHILADELPHIA BRANCH.

Organized February 18, 1903.

H. A. Foster. *Chairman.* H. F. Sanville, *Secretary.*

Managers.

J. Franklin Stevens, C. W. Pike, Paul Spencer.

PLACE AND TIME OF MEETING.

This Branch meets at the Engineers' Club, 1122 Girard Street, on the second Monday of every month.

The tenth regular meeting of this Branch was held April 11, 1904, 57 members and visitors attending. Kern Dodge read a paper entitled "The Electrical Equipment of the Janesville Iron Works." This paper was illustrated by lantern-slides, and was discussed by Messrs. Bedill, Dodge, Pike, Eglin, Hewitt, Gillette, Head, Perott, Kammacher, Ballinger, MacNair, Bonine, Keiser, and Rowland.

Another meeting of this Branch was held May 9, 1904, 51 members and visitors attending. At this meeting the High-Pressure Transmission papers presented at the 185th meeting, March 25, 1904, were presented and then discussed by Messrs. Eglin, Coles, Hewitt, Stitzer, Cheyney, Foster, Rowland, Eveleth, Morris, MacNair, J. S. Peck, Hutchings, and Spencer.

The 12th and annual meeting of the Philadelphia Branch was held June 13, 1904, 72 members and visitors attending. The officers named above were elected for the ensuing year:

Mr. L. D. Firman of the Electrical Bureau, described the fire telegraph system of the City Hall in Philadelphia. By courtesy of invitations from Chief Sager of the Electrical Bureau of the City Hall and Chief J. L. Baxter of the Fire Department, the INSTITUTE members and visitors inspected the Fire House at 21st and Market Streets, and witnessed a fire drill. They also inspected the electrical apparatus in the City Hall.

PITTSBURG BRANCH.

Organized October 13, 1902.

Paul M. Lincoln, *Chairman.* John S. Peck, *Secretary.*

Executive Committee.

P. M. Lincoln, J. S. Peck, C. Renshaw,
H. D. James, S. P. Grace.

PLACE OF MEETING.

The Electric Club, 735 Penn Ave., Wilkinsburg, Pa.

A meeting of this Branch was held May 5, 1904, 100 members and visitors attending. The INSTITUTE papers on "Alternating-Current Generators" presented at the 186th meeting, April 22, 1904, were abstracted and then discussed by Messrs. Karapetoff, Lincoln, Kintner, and Scott.

Another meeting of this Branch was held June 19, 1904, 75 members and visitors attending. Some of the papers presented at the annual meeting of the INSTITUTE, May 17–18, 1904, were abstracted and then discussed by Messrs. Kintner, James, Storer, Peck, Eckart, Dick, and Schmidt.

PITTSFIELD BRANCH.

Organized March 25, 1904.

F. A. C. Perrine, *Chairman.* D. B. Rushmore, *Secretary-Treas.*
C. C. Chesney, *Member of the Executive Committee.*

PLACE AND TIME OF MEETING.

Gate House of the Stanley Electric Mfg. Co., at stated intervals to be decided by the Executive Committee.

On March 24, 1904, an informal meeting of the Pittsfield members of the INSTITUTE was held at the Gate House of the Stanley Electric Manufacturing Company. The Secretary of the meeting was authorized to petition the INSTITUTE authorities for permission to form a Local Branch at Pittsfield.

On April 12, 1904, Messrs. F. A. C. Perrine, W. J. Lloyd, H. W. Tabey, H. C. Canfield, S. T. Dodd, L. V. Hastings, J. H. Hayes, S. H. Smith, H. Reid, J. J. Kline, G. Wright, and D. B. Rushmore met to organize the Pittsfield Branch of the INSTITUTE, necessary authority having been received by the temporary Secretary from the Board of Directors. At this meeting By-laws were proposed and adopted.

The first regular meeting of the Pittsfield Branch was held

April 18, 1904, 75 members and visitors attending. At this meeting President Arnold gave an address of welcome to the Pittsfield Branch. This was followed by a description of his work in Chicago and the electrification of the New York Central and Hudson River Railroad. Secretary Pope told of the early history of the INSTITUTE.

The second meeting of this Branch was held May 3, 1904, 55 members and visitors attending. The INSTITUTE papers on "Alternating-Current Generators" presented at the 186th meeting, April 22, 1904, were read and discussed.

Mr. Goggins described tests made on the 3500-kw. generators furnished the New York Edison Co. During these tests the machines were operated at full load on power-factors ranging from unity to 80 per cent., and actual measurements of regulation were obtained. This test was particularly interesting in view of a statement recently made by Mr. Behrend to the effect that it was not possible to obtain actual measurements of regulation at unity power-factor on machines as large as this.

Mr. Chesney spoke of the capacity of water-tanks and Mr. Carter gave results of some actual tests made by him indicating that considerable capacity exists. This point was also discussed by Messrs. Kelsey and Merrick.

Mr. Adams described tests on generators at Chambly. The mechanical construction of armature yokes was discussed by Messrs. Kimball, Power, and Adams.

Mr. Chesney spoke at length on Turbo-Alternator Construction and was followed by Mr. Tobey, who discussed the effect of the presence of the turbine on generator heating. Mr. Stovall followed with some data on air-gaps of alternators.

The third regular meeting of this Branch was held May 16, 1904, 65 members and visitors attending. The exercises of the evening consisted of an illustrated lecture on "Meters," by W. J. Lloyd. The lecture was confined to a description of instruments used for the measurement of current in the sale of electricity; about 75 lantern-slides were shown, illustrating the various forms of integrating and recording wattmeters which have been developed in the different countries, especially in England and the United States. Mr. Lloyd carefully explained the design and construction of the different instruments and brought out the good and bad points of each. It was of particular interest to note many peculiar varieties which have been developed in England. The American instruments appear very much simpler in design

and most of them are probably of a considerably cheaper cost for construction.

The fourth regular meeting of this Branch was held June 6, 1904, 50 members and guests attending. H. H. Barnes read his paper entitled "Notes on Fly-Wheels;" and J. J. Kline read Professor Rowe's paper entitled, "Wave Form Variations in Long-Distance Transmission Lines." The papers were then discussed by Messrs. Chesney, Adams, Henshaw, and Rushmore.

PURDUE UNIVERSITY BRANCH.

Organized January 20, 1903.

W. E. Goldsborough, *Chairman*. J. Walter Esterline, *Secretary*.

PLACE OF MEETING.

Electrical Engineering School, Purdue University.

The last reported meeting of this Branch was held April 20, 1904, 20 members and visitors attending. The INSTITUTE papers on High-Tension Transmission presented at the 185th meeting, March 25, 1904, were read and discussed.

ST. LOUIS BRANCH.

Organized January 14, 1903.

W. E. Goldsborough, *Chairman*. Gerard Swope, *Secretary*.

Executive Committee.

W. E. Goldsborough, Gerard Swope, H. H. Humphrey,
R. H. Klauder, Henry Rustin.

PLACE AND TIME OF MEETING.

Engineers' Club Rooms, St. Louis, second Wednesday of every month.

The 13th meeting of the St. Louis Branch was held April 13, 1904, 16 members and visitors attending. The INSTITUTE papers on High-Tension Transmission, presented at the 185th meeting, March 25, 1904, were read and then discussed by Messrs. Weaver, Timmermann, Landsdorf, and Howell.

SEATTLE BRANCH.

Organized January 19, 1904.

K. G. Dunn, *Chairman*. W. V. Sullivan, Jr., *Secretary-Treas.*

Executive Committee.

A. V. Joslin, S. C. Lindsay, W. S. Wheeler.

PLACE AND TIME OF MEETING.

Monthly meetings are held at the Maison Barberis on the second Saturday of every month.

A meeting of this Branch was held April 9, 1904, 15 members and visitors attending. An original paper entitled "The Olympia Water-Power Plant." was presented by Mr. Cummins; and an original paper entitled "Insulation of Electric Cables," by Mr. Buck, was read by Mr. Lindsay. The INSTITUTE papers relative to High-Tension Transmission presented at the 185th meeting, March 25, 1904, were also read and discussed.

Another meeting of this Branch was held April 14, 1904, 18 members and visitors attending. An original paper entitled "Rotary Converters" was presented by Mr. Lindsay (see June TRANSACTIONS, 1904). An original paper entitled "Electricity in the Klondike," was read by Mr. Roberson. These papers were then discussed by Messrs. Dunn, Lindsay, Joslyn, Allen, Wheeler, and Sullivan.

Another meeting of this Branch was held July 9, 1904. This meeting consisted of a trip to the Columbia Improvement Company's Power Plant at Electron, Washington. The members left Seattle July 9, *via* the Seattle and Tacoma Interurban Railroad. Luncheon was served by the Columbia Improvement Company at the power plant. In the evening the officials and engineers of the Columbia Improvement Company, accompanied by the members of the Seattle Branch, returned to Tacoma and held a dinner at the Tacoma Hotel.

SCHENECTADY BRANCH.

Organized January 26, 1903.

C. P. Steinmetz, *President.*

W. I. Slichter, A. E. Averett, *Vice-presidents.*

R. Neil Williams, *Secretary.*

G. W. Cravens, *Recording Secretary.*

C. E. Eveleth, *Treasurer.*

H. E. White, *Librarian.*

The last reported meeting of this Branch was held May 31, 1904, 80 members and visitors attending. The two INSTITUTE papers entitled "Predetermination of Sparking in Direct-Current Machines," by W. L. Waters, and "Effect of Self-Induction on Railway Motor Commutation," presented at the 187th meeting, May 17–18, 1904, were abstracted and discussed by E. H. Anderson.

TORONTO BRANCH.

Organized May 28, 1903.

T. R. Rosebrugh, *Chairman.* H. A. Moore, *Vice-chairman.*
R. T. MacKeen, *Secretary.*

Executive Committee.

J. A. Kammerer, K. L. Aitken, R. G. Black.

TIME AND PLACE OF MEETING.

This Branch meets at the Engineers' Club on the Second Friday of every month.

A meeting of this Branch was held April 8, 1904, 15 members and visitors attending. The INSTITUTE papers on High-Pressure Transmission presented at the 185th meeting, March 25, 1904, were abstracted and then discussed by Messrs. Boyd, McKay, Black, Aitken, Wright, McBurney, Rosebrugh, and MacKeen.

Another meeting of this Branch was held May 13, 1904, 18 members and visitors attending. An original paper entitled "Storage-Batteries" was presented by Ewart B. Walker, and discussed by Messrs. Rosebrugh, Hamilton, Angus, Black, Kammerer, Aitken, Wise, and Richards.

The annual meeting of this Branch was held June 10, 1904. The officers named above were elected to serve during the ensuing year. At this meeting an original paper entitled "The Toronto Niagara Power Transmission Development," was presented by K. L. Aitken.

WASHINGTON BRANCH.

Organized April 9, 1903.

Samuel Reber, *Chairman.* Philander Betts, *Secretary.*

Executive Committee.

F. A. Wolff, W. H. Tapley, E. E. Clement.

PLACE AND TIME OF MEETING.

This Branch meets at the Columbian University on the first Thursday of every month.

A meeting of this Branch was held at the North Telephone Exchange, March 10, 1904, 94 members and visitors attending. J. M. C. Graham, Superintendent of Maintenance of the Chesapeake & Potomac Telephone Company, read an original paper describing the engineering features of the North Exchange.

Another meeting of this Branch was held April 14, 1904, 50 members and visitors attending. At this meeting there were exhibited and described the telautograph, the speaking telephone, the writing telegraph, and other special apparatus used by the Signal Corps of the United States Army.

Another meeting of this Branch was held May 5, 1904, 42 members and visitors attending. W. H. Tapley, Electrical Engineer of the Government Printing Office, gave a detailed description of the electrical equipment of the Government Printing Office at Washington. The lecture was illustrated by an experimental demonstration of the working of a special motor-starter, and by many curves, tables, and other data.

The annual meeting of this Branch was held June 9, 1904. The officers named above were elected to serve during the ensuing year.

WASHINGTON UNIVERSITY BRANCH.

Organized February 26, 1904.

A. S. Langsdorf, *Secretary*.

PLACE AND TIME OF MEETING.

Washington University, second and fourth Tuesdays of every month.

The last reported meeting of this Branch was held April 26, 1904. Five members and visitors attended. The INSTITUTE paper entitled "The Mechanical Construction of Revolving Field Alternators," was abstracted and discussed.

UNIVERSITY OF WISCONSIN BRANCH.

Organized October 15, 1902.

B. V. Swenson, *Chairman*. G. C. Shaad, *Secretary*.

PLACE AND TIME OF MEETING.

This Branch meets at the Engineering Building, State University, every Thursday during the college year.

A meeting of this Branch was held April 20, 1904, 22 members and visitors attending. The INSTITUTE papers on High-Pressure Transmission, presented at the 185th meeting, March 25, 1904, were read, and then discussed by Messrs. Kellar, W. B. Jackson, Swenson, Mallett, Shuster, King, and Fetherling.

Another meeting of this Branch was held May 19, 1904, 19 members and visitors attending. The INSTITUTE papers on

Alternating-Current Generators, presented at the 186th meeting, April 22, 1904, were abstracted and discussed.

Another meeting of this Branch was held July 8, 1904, 10 members and visitors attending. The INSTITUTE papers presented at the annual meeting, May 17–18, were abstracted and discussed.

WORCESTER POLYTECHNIC INSTITUTE BRANCH.

Organized March 25, 1904.

Joseph A. Johnson, *President.* Willis L. Towne, *Vice-president.*
Charles H. Gilbert, *Secretary-Treasurer.*

Executive Committee.

H. B. Smith, Ernest C. Morse, Albert T. Childs.

PLACE AND TIME OF MEETING.

Electrical Engineering Lecture Room, September 30, October 14, November 11, December 9, 1904; January 6, February 10, March 10, April 21, May 12, 1905.

The last meeting of the Electrical Engineering Society of the Worcester Polytechnic Institute was held May 18, 1904. At this meeting an original paper entitled "Estimates on the Electrification of the Boston and Albany Railroad, between Boston and Worcester," was presented by A. P. Davis of the Class of 1901.

After the reading of this paper a business meeting of the society was called for the purpose of deciding upon the organization of a Branch of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. A new constitution was brought up for discussion. Many points as to membership and officers of such a branch were fully considered. It was voted that all members of the old society should be considered as charter members of the Branch; also any resident Member or Associate of the A. I. E. E. and all students of the Electrical Enigneering course at W. P. I. might join the Branch.

GENERAL INSTITUTE MATTERS.

The 188th meeting of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS was held in the Assembly rooms of the Western Society of Engineers, Monadnock Block, Chicago, June 21–22, 1904.

FIRST SESSION.

10 a. m.–12.30 p. m., JUNE 21, 1904.

PRESIDENT ARNOLD: It is gratifying to see so many assembled here this morning.

SECRETARY POPE: The papers to be discussed are contained in the two pamphlets which have just been distributed; one pamphlet contains the six papers prepared especially for this meeting under the direction of the High-Tension Transmission Committee; the other pamphlet contains Answers to a List of Questions sent out about 15 months ago in regard to High-Tension Transmission, and is now presented as a report from the High-Tension Transmission Commiteee.

PRESIDENT ARNOLD: We will commence our programme with the reading of the paper entitled, "Line Construction with Steel Supporting Structures and Long Spans," by F. O. Blackwell. (For paper see page 555 May TRANSACTIONS, 1904. For discussion on this paper see October TRANSACTIONS, 1904.)

PRESIDENT ARNOLD: We will now listen to the next paper entitled, "Protection of Cables from Arcs Due to Failure of Adjacent Cables," by W. G. Carlton, and then discuss both of them. (For paper see page 539 May TRANSACTIONS, 1904; for discussion on this paper see page 712, September TRANSACTIONS, 1904.)

PRESIDENT ARNOLD: In discussing Mr. Blackwell's paper we have practically taken up the subject contained in Mr. Wirt's paper, which will now be read. "The Protection of High-Pressure Transmission Lines from Static Discharges," by H. C. Wirt. (For paper see page 571 May TRANSACTIONS, 1904; for discussion on this paper see page 699 September TRANSACTIONS, 1904.)

SECOND SESSION.

2.30 p. m.–5.30 p. m., JUNE 21, 1904.

PRESIDENT ARNOLD: We will begin this afternoon's meeting with the reading of the paper entitled, "The Use of Ground-Shields in Transformers," by John S. Peck. (For paper see page 569 May TRANSACTIONS, 1904; for discussion on this paper see page 709 September TRANSACTIONS, 1904.)

PRESIDENT ARNOLD: We will now have the paper entitled "Conditions for Continuous Service over Lines Operated in Parallel," by M. H. Gerry, Jr. Mr. Mershon will please read the paper. (For paper see page 565 May TRANSACTIONS, 1904; for discussion on this paper see page 711 September TRANSACTIONS, 1904.)

THIRD SESSION.

10 a. m.–12.30 p. m., JUNE 22, 1904.

PRESIDENT ARNOLD: We will have the paper entitled, "Synchronous Motors for the Regulation of Power-Factor and Line Voltage," by B. G. Lamme. Mr. Peck will please read the paper. (For paper see page 543 May TRANSACTIONS, 1904; for discussion on this paper see October TRANSACTIONS, 1904.)

PRESIDENT ARNOLD: After adjournment this morning it is desired that we meet again in these rooms promptly at two o'clock. We will then go to 176 Fifth Avenue where we will take an elevator to the Freight Distributing Subway of the Illinois Tunnel Company underneath the city. We will go on a special train, to be shown beneath the business portion of the city. We will be shown how to get freight from the various subway tunnels into the city and then into the buildings without going to the surface of the street. After the trip through the tunnel we will reassemble here and continue the discussion of the transmission papers, so that we may adjourn promptly at 5.30 o'clock and take a boat to the entertainment for the evening.

FOURTH SESSION.

2.30 p. m.–5.30 p. m., JUNE 22, 1904.

PRESIDENT ARNOLD: We will now begin a general discussion on all the High-Tension Transmission papers and also on the Report of the High-Tension Transmission Committee.

The Report of the High-Tension Transmission Committee consists principally of questions and answers thereto. These questions and answers and the papers on High-Tension Transmission matters presented at this and at other meetings of the INSTITUTE during the last 15 months represent the active work of the Committee. The suggestions which have been tendered by the Committee are very encouraging to those who are directing the work of the INSTITUTE at the present time. Mr. Mershon as chairman will now tell us about the work of the High-Tension Transmission Committee.

RALPH D. MERSHON: When the High-Tension Transmission Committee was appointed one of the first things it did was to send out a printed list of 187 questions to various ransmission plants; the idea being, if possible, to obtain data on the design of plants now in operation and the results of their operation. This list of questions, which no doubt many of you have seen, covers the subjects of line construction and operation, the method of connection of transformers, lightning protection, telephone lines, etc.—in fact, all the vital points in connection with a transmission plant. At least 250 of these lists of questions were distributed. Of this number 47 were returned filled out, and this report contains the most valuable information derived from the answers in these 47 lists of questions. The information has been partly tabu-

lated, while the balance has been put into the shape submitted.

A good many of the answers and reasons given may be found vague or obscure; in such cases the original answers were not clear and were inserted just as you see. The last few pages of the report are given to details of line construction; these pages contain tables and the original illustrations sent out with the list of questions. In final form this information will be arranged in a way convenient for ready reference, and, due to Dr. Perrine's suggestion, the tables will contain the volts per mile for the different classes of plants. In the first table are given the voltages, lengths of lines, power-factors, frequencies, etc. It was not appreciated before that there were in use in this country so many frequencies. The range of power-factor is also interesting, some of the power-factors being surprisingly high, while others are surprisingly low. One point on which the information is of considerable value is the distance between conductors, as this question has been under discussion for a long time. Data from plants which are presumably successful are here given and should furnish a criterion as to the relation which should exist between voltage and distance between conductors to satisfy practical conditions.

(For Report see page 661 September TRANSACTIONS, 1904; for discussion on this Report see page 695 September TRANSACTIONS, 1904.)

CHARLES F. SCOTT: This meeting of the INSTITUTE owes its thanks to the Transmission Committee and particularly to its Chairman, and therefore the speaker moves that the President express the gratitude of the INSTITUTE to Mr. Mershon.

PRESIDENT ARNOLD: Mr. Mershon, the President extends the thanks of this meeting and of the INSTITUTE to you and your Committee.

It is also moved and seconded that a vote of thanks be given to the Local Committee for the work they have done in connection with this meeting.

(The motion was carried unanimously.)

The meeting will now adjourn and be entertained by the local members at the Chicago Yacht Club. Immediately after the close of this meeting carriages will convey the members to the Chicago Yacht Club for dinner; after dinner we will board the United States Naval Reserve boat Dorothea.

After the adjournment of the meeting the following telegraph message was delivered at President Arnold's home in Chicago:

MONTEREY, CALIFORNIA, June 22, 1904.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, CHICAGO:

In convention assembled we meet in synchronism with you and transmit high-tension greeting.

(Signed)

PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION.

ASSOCIATES ELECTED JULY 19TH, 1904.

ADAMS, FRANCIS JOSEPH, Student Worcester Polytechnic Institute, Worcester; res., Westboro Hospital, Westboro, Mass.	H. B. Smith. J. O. Phelon. A. P. Davis.
ANDEREGG, GUSTAVUS ADOLPHUS, Laboratory Assistant, Western Electric Company; res., 332 W. 19 St., New York City.	C. A. Adams. G. A. Hamilton. S. E. Whiting.
ANDERSON, WILLIAM FELL, Superintendent Spier Falls Power Station, The Hudson River Water Power Co., Glens Falls, N. Y.	E. B. Raymond. J. D. Hilliard. B. E. Morrow.
BARNHART, WILLIAM O., Chief Engineer of Station, North Shore Electric Co.; res., 908 Clark St., Evanston, Ill.	H. M. Hope. G. H. Lukes. L. A. Ferguson.
BATES, GEORGE MOULTON, Sales Agent and Electrical Engineer, Westinghouse Electric and Mfg. Co.; res., 75 Maple St., Waltham, Mass.	C. F. Scott. N. C. Ross. P. M. Lincoln.
BOURNE, CHARLES OSCAR, Electrician, U. S. Navy Yard, Boston; res., 7 Henry St., West Somerville, Mass.	C. B. Burleigh. C. S. Davis. C. W. Parks.
BRUNDIGE, JOHN ALVIN, Assistant, Niagara Construction Co., Ltd., Box 3, Niagara Falls, N. Y.	V. G. Converse P. N. Nunn. H. B. Shaw.
BURCH, ORRIN, Draftsman, Union Carbide Co., 518 Court St., Saulte Ste Marie, Mich.	B. F. Thomas. F. A. Fish. E. F. Price.
CARIAPA, CODANDA M., Student, General Electric Co.; res., 1 State St., Schenectady, N. Y.	C. C. Parks. E. B. Raymond. B. D. Nath.
CONDIT, BENSON CLARE, Superintendent, American River Electric Co., 334 Weber Ave., Stockton, Calif.	F. G. Baum. F. A. C. Perrine. G. J. Henry, Jr.
CONDIT, CLYDE ERNEST, Superintendent, Tonopoh Light and Power Co., Tonopoh, Nev.	F. G. Baum. F. A. C. Perrine. C. W. Waller.
ELLS, FREDERICK WILLIAM, Chief Engineer, Browning Mfg. Co., Milwaukee, Wis.	David Hall. W. F. Wells. R. W. Pope.
EWING, THOMAS, JR., Ewing, Whitman & Co., 67 Wall St., New York; res., Yonkers, N. Y.	J. J. Carty. G. S. Dunn. R. W. Pope.
FACCIOLI, GUISEPPE, Crocker-Wheeler Co., Ampere; res., 280 4th St., Jersey City, N. J.	G. S. Dunn. J. W. Lieb, Jr. L. B. Stillwell.
FAHNESTOCK, J. HARVEY, Inspector, Chesapeake and Potomac Telephone Co.; res., 1107 10th St., N. W., Washington, D. C.	J. P. Jackson. J. N. G. Nesbit. O. A. Estes.
FRENCH, EDWARD VINTON, Inspector (Special), Associated Factory, Mutual Fire Insurance Cos., 31 Milk St.; res., 22 Park St., Boston, Mass.	C. M. Goddard. Calvin W. Rice. W. L. Puffer.
GAVIT, WILLIAM EDMONDS, Treasurer, Tucker Electrical Construction Co.; res., 107 Bay 25th St., Brooklyn, N. Y.	H. A. Sinclair. C. O. Mailloux. E. R. Knowles.

GEIB, ADAM, Sub-station Foreman, New York City Railway Co.; res., 10 West 133 St., New York City.	George Graves. F. G. Clark. F. G. Robinson.
GOODE, HENRY W., President, Portland General Electric Co., Portland, Oregon.	W. S. Barstow. C. A. Coffin. C. F. Scott.
GRIER, ARTHUR GORDON, Engineer, Western Electric Co.; res., 35 E. 46 St., Chicago, Ill.	C. C. Chesney. F. A. C. Perrine. H. W. Tobey.
HOOPER, JAMES KIMBALL, Inspector and Agent, New York Edison Co,, New York; res., 193 Sterling Place, Brooklyn, N. Y.	C. K. Nichols. R. A. Davidson. Arthur Williams
HURLBERT, FRANCIS WYMOND, Foreign Dept., General Electric Co., 44 Broad St., New York City.	Calvin W. Rice. W. J. Clark. M. A. Oudin.
HYATT, CHARLES EDWARD, Designing Engineer, Crocker-Wheeler Co., Ampere; res., 239A Mt. Prospect Ave., Newark, N. J.	F. W. Hall. G. S. Dunn. E. R. Carichoff.
KERN, OSCAR FREDERICK, Station Attendant, Mt. Whitney Power Co., Three Rivers, Cal.	C. H. Holly. C. L. Cory. R. W. Pope.
KING, HARRY DEGOLIER, Superintendent, Public Service Corporation of N. J., 14th and Bloomfield Sts.; res., 1018 Hudson St., Hoboken, N. J.	A. F. Ganz. W. B. Jackson. Louis Wintner.
LANGAN, JOHN, Salesman, Okonite Co., 253 Broadway, New York City.	R. C. Taylor C. E. Roehl. J. D. Keiley.
LEBENBAUM, PAUL, Draftsman, Southern Pacific Co.; res., 2775 Clay St., San Francisco, Cal.	A. H. Babcock. C. L. Cory. R. W. Pope.
LEWINSON, LEONARD JULIAN, Student, Columbia University; res., 129 East 95 St., New York City.	G. F. Sever. Fitzhugh Townsend. Morton Arendt
LIGHTHIPE, WILLIAM WILSON, Superintendent, Marine Engine and Machine Co., 143 W. 24 St., New York; res., 203 Bay 31 St., Bensonhurst, L. I., N. Y.	Morton Arendt. G. F. Sever. B. N. Jones.
MACY, OLIVER CROSBY, Electrician and Engineer, New England Structural Co., 49 Morris St., Everett, Mass.	C. B. Burleigh. R. B. Hampson. G. E. Fisher.
MARSTON, ANSON, Dean of Division of Engineering, Iowa State College, Ames, Iowa.	B. S. Lanphear. G. W. Bissell. L. B. Spinney.
MARVIN, RICHARD HALE, Laboratory Assistant, Edison General Electric Co., 373 Franklin St., Bloomfield, N. J.	J. W. Howell. J. S. Marshall. A. F. Ganz.
MATEER, JESSE EUGENE, Electrical Engineer, Westinghouse Electric and Mfg. Co., Pittsburg; res., 907 Center St., Wilkinsburg, Pa.	J. S. Peck. C. E. Skinner. C. F. Scott.
MCKEE, WILLIAM NORRIS, General Manager, Moweaqua Electric Co., Moweaqua, Ill.	H. C. Cushing. W. A. Kreidler. R. C. Lanphier.
MEYGRET, ACHILLE, Inventor, 238 W. 53 St., New York City.	Leo Daft. Jean Lavergne. R. W. Pope.

MOORE, HAROLD THOMPSON, Mechanical Engineer, Dodge and Day; res., 4535 Pulaski Ave., Germantown, Philadelphia, Pa.	H. F. Sanville. Kern Dodge. Charles Day.
MYERS, ROMAINE WRIGHT, Expert Electrician, United States Engineers, 89 Flood Building, San Francisco; res., Fruitvale, Cal.	J. A. Lighthipe. H. A. Russell. R. W. Pope.
NOBLE, GUY HINCHMAN, Salesman, Stanley Electric Mfg. Co.; res., Somerville, N. J.	H. H. Barnes. C. C. Chesney. S. T. Dodd.
RIDDLE, JERRY BOGGS, Superintendent, Ashburton Mining Co., Fair Oaks, Cal.	Lawrence Ettrup. R. H. Black. C. W. Hutton.
ROBINSON, EDWIN GARDNER, JR., Superintendent, Ballard Electric Co., Ballard, Wash.	K. G. Dunn. W. V. Sullivan. R. W. Pope.
SCHICK, DANIEL FREDERICK, Foreman, Philadelphia Electric Co.; res., 1521 Franklin St., Philadelphia, Pa.	J. T. Hutchings. A. J. Rowland. W. C. L. Eglin.
SUHR, OTTO BRUNO, Engineer in charge, Ontario Power Co., Box 3, Niagara Falls, N. Y.	F. B. H. Paine. V. G. Converse. M. H. Gerry, Jr.
TRACY, FRED GLYNDON, Manager, C. G. Tracy and Co., Glyndon, Minn.	J. C. Dow. F. W. Springer. W. L. Kinsell.
VAN COTT, LINCOLN, Purchasing Agent, Brooklyn Heights R. R. Co.; res., 188 Henry St., Brooklyn, N. Y.	J. D. Keiley. W. H. Sawyer. Samuel Sheldon.
VER PLANCK, WILLIAM EVERETT, Assistant Engineer, General Electric Co.; Lynn, Mass.	G. F. Sever. Elihu Thomson. H. V. Hayes.
WALES, SAMUEL SIGOURNEY, Electrical Engineer, Homestead, Steel Works, Munhall, Pa.	A. C. Dinkey. C. F. Scott. E. B. Clark.
WARREN, HALBERT B., Chief Engineer, Warren Electric Mfg. Co., Sandusky, O.	C. C. Curtis. Jas. I. Ayer. R. W. Pope.
WHITTLESEY, WILLIAM AUGUSTUS, Treasurer and Manager, Pittsfield Electric Co.; res., 135 East Housatonic St., Pittsfield, Mass.	F. A. C. Perrine. C. K. Stearns. R. W. Pope.
WRIGHT, REUBEN IRVING, Assistant Engineer, Electric Controller and Supply Co., 4 North Olive St., Cleveland, O.	A. C. Eastwood. R. A. White. C. A. Adams.
YAWGER, THOMAS H., Assistant Superintendent, Rochester Gas and Electric Co., 84 Anderws St.; res., 92 Linden St., Rochester, N. Y.	G. A. Redman. J. E. Putman. C. T. Mosman.

Total, 50.

ASSOCIATES TRANSFERRED TO THE GRADE OF MEMBER.

WILLIAM HEMENWAY PRATT, Designing Engineer, General Electric Co., Lynn, Mass.

LOUIS BEVIER SPINNEY, Professor of Physics and Electrical Engineering, Iowa State College, Ames, Iowa.

EDWIN BRITTON KATTE, Electrical Engineer, N. Y. C. & H. R. R. R. Co., New York City.

GILBERT ROSENBUSCH, Engineer-in-charge, Design and Installation, Waygood & Otis, Ltd., London, Eng.

DWIGHT PARKER ROBINSON, in charge Engineering Dept. Stone & Webster, Boston, Mass.

CHARLES HENRY WILMERDING, Consulting Engineer, Chicago, Ill.

BANCROFT GHERARDI, Chief Engineer, N. Y. & N. J. Telephone Co., Brooklyn, N. Y.

ASSOCIATES ELECTED AUGUST 17TH, 1904.

ALLCOCK, H., Manchester, Eng.	T. E. Ritchie. R. W. Pope. C. H. Wordingham
ANDRAE, ROBERT TURNER, Student Testing Department, General Electric Co.; res. 1 State St., Schenectady, N. Y.	E. B. Raymond. R. W. Pope. B. D. Nath.
BEGGS, JOHN IRVIN, President and General Manager, Milwaukee Electric Railway and Light Co.; res. Hotel Pfister, Milwaukee, Wis.	W. V.N. Powelson. W. F. White. F. L. Hutchinson.
BEVAN, TOM WILLIAM, Superintendent of Power Houses, Sao Paulo Tramway Light and Power Co., Sao Paulo, Brazil, S. A.	L. L. Perry. R. C. Brown. J. J. Mahony.
BUNJE, CHARLES, JR., Draughtsman, Public Service Corporation of New Jersey; res. 14 Webster Ave., Jersey City, N. J.	A. F. Ganz. D. S. Jacobus. E. C. Johns.
CARD, JOHN FRANCIS, Designing Engineer and Superintendent, Three Rivers Electric Co.; res. 310 Flint Ave., Three Rivers, Mich.	Thomas Duncan. R. W. Pope. F. S. Hunting.
CASSIER, LOUIS, Editor, Cassier's Magazine; 3 West 29th St., New York City.	C. W. Rice. E. H. Mullin. C. W. Hunt.
CRESSY, LOUIS AGASSIZ, Shop Electrician, Electric Vehicle Co.; res. Quaker Lane, West Hartford, Conn.	W. L. Robb. H. J. Blakeslee. Joseph Sachs.
DANN, WALTER MELVILLE, Engineering Apprentice, Westinghouse Electric and Mfg. Co.; res. 1106 Center St., Wilkinsburg, Pa.	C. F. Scott. P. M. Lincoln. C. E. Downton.
GARZA, JOSE MARIA, Testing Department, General Electric Co., Schenectady, N. Y.	A. F. Ganz. D. S. Jacobus. R. W. Pope.
HAYES, ALBERT EARLE, Designing Engineer, General Electric Co.; res. 28 Atlantic Terrace, Lynn, Mass.	Richard Fleming. A. R. Everest. H. B. Smith.
HILL, HALBERT PAUL, District Manager, Bullock Electric Mfg. Co., 1505 Chemical Building. St. Louis.	Max Osterberg. R. W. Pope. F. L. Hutchinson.
HILL, W. H., Assistant Superintendent, Con. Dept., New York Edison Co., New York City; res. 1032 Greene Ave., Brooklyn, N. Y.	Philip Torchio. J. W. Lieb, Jr. W. I. Donshea.
HOLLAND, WALTER E., Tester, Edison Storage Battery Co., Silver Lake; res. 211 Arlington Ave., East Orange, N. J.	J. W. Aylsworth. T. A. Edison. R. A. Fliess.
HOLTBY, ALFRED CHARLES, Consulting Electrical Engineer, S. Newman & Co., Johannesburg, S. A.	J. W. Kirkland. A. W. K. Peirce. H. G. Spengel.

HOOPES, WILLIAM, Electrical Engineer, Pittsburg Reduction Co., Pittsburg, Pa.	R. D. Mershon. C. F. Scott. Maurice Hoopes.
HOLMGREN, TORSTEN, Partner and Chief Engineer, Drottninggatan 26, Stockholm, Sweden.	Charles Hassler. E. Danielson. K. A. Lindstrom.
INCH, SYDNEY RICHARD, Superintendent and Manager, Missoula Light and Water Co., Missoula, Mont.	B. E. Semple. James Lyman. C. W. Rice.
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MEMOIRS OF DECEASED MEMBERS.

ERNEST KEMPTON ADAMS.

Ernest Kempton Adams was born December 17, 1873, at Boston, Mass., and died July 21, 1904, at Watkins, N. Y. He was the son of Edward D. and Frances A. Adams. He was graduated at the Sheffield Scientific School, Yale University, with the class of '96, receiving the degree of Ph.B. While at Yale he was an editor of the *Sheffield Scientific Monthly*. He took a post-graduate course in the Electrical Engineering Department of Columbia University, being graduated with the class of '97, with the degree of E. E., and with the class of '98 with the degree of A. M.

As a draughtsman and mechanician he had few equals among his contemporaries; his skill and precision in this direction could only be appreciated by those to whom he was willling to make disclosures, for he was by nature somewhat diffident. While under Professor Crocker, at Columbia, he made a series of dynamo drawings which to-day hang on the walls of the Electrical Engineering Department, being exhibited as the best examples of such work done by any student there. Several of these drawings were of motors and dynamos of his own design.

The electrical press has printed from time to time several articles from his pen. Among these were articles dealing with electrical and other methods for repeating and verifying the famous Foucault pendulum experiments illustrating the earth's rotation. Aside from experimental work he was the author of many devices of practical value, especially such as depend upon exact and accurate movements. One of his devices was a system for station annunciation on electric railways. This he developed with great persistence in spite of dogging sickness.

A literary record of Mr. Adams' work will soon be published in two quarto volumes, most of the manuscript having been compiled by Mr. Adams himself. These volumes will contain descriptions and illustrations of more than 200 inventions and improvements made by him in matters physical, electrical, musical, and mathematical.

Mr. Adams was a member of a number of social and scientific organizations, among them being the Grolier Club, the Metropolitan Museum of Art, the Museum of Natural History, the New York Botanical Gardens, the New England Society,

the Metropolitan Club, the City Club, the Riding Club, the Sons of the Revolution in the State of New York, the Columbia Alumni Association, the Yale Alumni Association, and the Yale Chapter of the Sigma Xi (honorary scientific) Fraternity. He was elected an Associate of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS on July 29, 1898.

Mr. Adams was married in 1902 at the Emperor William Memorial Church, in Berlin, to Miss Margaret Seefeld, whose father was Military Commander of the Grand Duchy of Baden. He is survived by Mrs. Adams and a child one year old. He was buried at the family mausoleum, Kensico Cemetery, the last week of July, 1904.

SECTION II.

PAPERS AND DISCUSSIONS.

This section contains INSTITUTE matters of a permanent nature; these matters will be eventually reproduced in the bound volume compiled at the end of the calendar year.

A paper presented at the 188th Meeting of the American Institute of Electrical Engineers, Chicago, Ill., June 21-22, 1904.
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ANSWERS TO QUESTIONS RELATIVE TO HIGH-TENSION TRANSMISSION.

At a meeting of the Board of Directors of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, held September 26, 1902, it was

"RESOLVED, That a Committee on High-Tension Transmission, consisting of five members, may be appointed for the purpose of collecting data respecting present practice in electric transmission at high voltage and of presenting a report which will indicate the successful methods which are now in operation in such form as to be of immediate value to electrical engineers. It is within the scope of the Committee to secure data upon line construction, insulators, pins and the like, and the conditions of operation at different voltages and under different climatic conditions; to investigate methods of testing insulators and to indicate the method or methods which in its judgment are superior. Also to ascertain the methods employed for voltage regulation, the conditions attendant upon the switching of high-tension circuits and to collect data respecting lightning and static disturbances and the use of grounded protective wires."

In accordance with this resolution the Transmission Committee prepared a list of questions, copies of which were sent to those connected with and operating transmission plants, with the request that the answers to the questions be filled in and the lists returned. Although the number of replies received fell far below the number hoped for, a considerable amount of information was obtained. The following matter presents in condensed form the answers received. For convenience in presentation, the plants have been classified with respect to the voltage of transmission.

Total number of plants that have filled out lists to date, 47. These plants are classified as follows:

Class A. Plants transmitting under 12 500 volts.
B. Plants transmitting from 12 500 to 19 000 volts.
C. Plants transmitting from 20 000 to 24 000 volts.
D. Plants transmitting from 25 000 to 29 000 volts.
E. Plants transmitting from 30 000 to 39 000 volts.
F. Plants transmitting from 40 000 to 60 000 volts.

I. LINE IN GENERAL.

3. *What is the distance of transmission?*
4. *What is the transmission voltage at the generating end and at the receiving points?*
5. *Is the transmission single-phase, quarter-phase (two-phase), or three-phase?*
6. *What is the frequency?*
7. *How much power is transmitted?*
8. *What is the average power-factor at the generating station and at the sub-stations?*
14. *What is the distance between conductors?*

(For answers to these questions see Table A.)

TABLE A.

Class.	Number of plants.	Transmission voltage.			Total milepage of transmission lines.	Total power transmitted in kilowatts.	Length of Lines in miles.			Phase			Frequency, cycles per second.							Range of power-factor	Distance between conductors in inches		
		Maximum.	Minimum.	Average.			Maximum.	Minimum.	Average.	Single	Two	Three	25	30	33	50	60	66		Maximum.	Minimum.	Average.
A	19	12 000	4 600	8 000	217	31 135	25	3	9.5	1	4	14	2	1	2	—	14	2	80 to 100	36	14	19
B	7	16 000	14 500	15 000	297	65 425	31	7	23	—	—	7	2	1	—	1	3	—	80 to 97	40	18	27
C	9	24 000	20 000	22 600	394	64 999	60	107	32	—	—	9	2	1	—	—	5	1	80 to 90	48	26	33
D	4	27 000	25 000	25 500	127.50	23 400	46	16.6	32	—	—	4	—	—	—	—	3	1	80 to 90	50	18	39.5
E	4	34 000	30 000	31 300	276.30	18 825	83	29	62	—	—	4	1	—	—	1	2	—	90 to 95	40	24	31
P	4	60 000	40 000	51 600	328.25	14 875	101	60	75	—	—	4	—	1	—	—	3	—	65 to 100	108	42	76

12. *How many complete circuits are there on each pole line?*
13. *What is the standard distance of the lowest conductors above the ground?*
15. *What length of span is standard?*
16. *What is the longest span used with standard construction or modification of it?*
24. *What is the greatest deflection of line ordinarily allowed on a single angle-pole?*
25. *Do angle-poles have double fixtures?*
26. *Are angle-poles braced or guyed? If guyed, at what point relative to the power wires are the guys attached? (A sketch is desirable.)*
27. *What is the normal length of span between angle-poles?*
28. *If guys are used, do you use strain insulators in the guys?*
32. *Are the power wires transposed? If so, how many times and at what intervals of distance?*

(For answers to these questions see Table B.)

TABLE B.

Class.	Max. no. of complete circuits on one pole line.	Height lowest conductor is above the ground in feet.	Standrd length of span feet.	Longest span with standard const. feet.	Max deflection allowed on ordinary single pole (horizontal.)	No. of plants using double fixture on angle-poles.	No. plants that guy or brace angle-pole.	Length of span between angle-poles.	No. of plants using strain insulations in guys.	No. of plants that transpose lines.
A	9	18 to 40	80 to 125	100 to 240	10° to 90°	17	15G. 2G&B	50 to 130	11	8
B	3	15 to 32	80 to 125	100 to 175	10° to 60°	6	7G	20 to 100	6	5
C	2	15 to 27	90 to 140	100 to 300	12° to 30°	9	3G 2B 4G&B	12 to 100	4	8
D	2	25 to 35	90 to 130	125 to 200	15° to 45°	4	1G 2B 1G&B	50 to 90	2	3
E	2	19 to 27½	100 to 130	360 to 400	45°	3	3G 1B	80 to 120	1	4
F	1	19½ to 30	100 to 180	200 to 320	10°	1	1G 1G&B	110	0	4

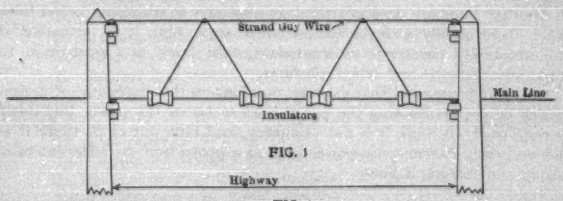


FIG. 1

18. *What heavier construction, if any, is used on such spans?*
19. *What is the longest span of any kind?*
20. *What is the distance between wires on this span?*

GENERAL DESCRIPTION OF CONSTRUCTION USED IN EXTRA-LONG SPANS.

Spans to 300 feet: the poles are usually double cross-armed and guyed; in some cases double poles are also used.

Span 626 feet: double poles, double cross-arms guyed two ways, and wires were spaced eight feet apart.

Span 800 feet: double poles and 6 by 6 in. cross-arms, poles guyed with steel cable two ways.

Span 586 feet: six poles, two poles for each wire, a cross-arm bolted on top of each pair of poles with four insulators in it; the six poles are framed together and braced in all directions.

Span 1750 feet: two poles set 10 feet apart, 66 feet high, 10 in. tops, ⅜ in. steel cable was used on this span, it being constructed to take the place of a pole line across a dry river bed in case of washout. Factor of safety is only 1.6 on this span and has withstood winds of 90 miles per hour. It is supported by compression strains on insulators whose pins stand radially around the beam; six feet between wires.

Span 400 feet: four poles set same as a tower and held together, also guyed; double cross-arms, wires spaced four feet apart.

34. *Do you consider transposition necessary so far as the power line itself is concerned? If so, why?*
35. *Do you consider the transposition of the power lines necessary for the protection of adjacent telephone and telegraph wires?*

REASONS FOR TRANSPOSING POWER LINE.

One company thinks transposing of power lines is not necessary for lines up to 30 miles and voltages under 20 000, but for distances and voltages in excess of these, thinks it better as power wires are more symmetrically located as regards the earth.

One company does not think transposing is necessary when synchronous converters are used at intervals along the line.

One company thinks it is decidedly necessary to transpose power lines their principal reasons are; the lack of interference with telephone and telegraph wires running parallel, and the more spiralling, the less apparent impedance.

Another company does not think it necessary to transpose power lines when there is only a single line on poles; they think it is advisable if not absolutely necessary to transpose power lines as a protection to adjacent telephone and telegraph lines.

Out of 23 companies that express opinions on the necessity of transposing or not transposing the power lines so far as the power line itself is concerned, 15 think it is not necessary, and nine out of 20 think it is not necessary to transpose power lines as a protection to adjacent telephone and telegraph lines.

29. *Are braces used on the cross-arms? If so, of what material and how constructed? (A sketch is desirable.)*
30. *How are the cross-arms attached to the poles, and how deep are poles gained?*

METHODS OF BRACING AND FASTENING CROSS-ARMS TO POLES.

Class A.

Majority of cases, strap-iron braces 1¼ by ¼ in. are used.
In one case angle-iron braces are used.
In three cases strap-iron galvanized braces are used.
In one case no bracing is done.
In eleven cases through bolts are used to fasten cross-arm to pole.
In six cases lag-screws are used to fasten cross-arm to pole.
Through bolts average from ⅝ to ¾ in. in diameter.
Poles are gained from ½ to 3 in. deep.

Class B.

Strap-iron braces are used in all cases.
In one case the strap-iron braces were galvanized.
In four cases through bolts were used to fasten cross-arm to pole.
In three cases lag-screws were used to fasten cross-arm to pole.
Gains ½ to 2 in. deep.

Class C.

In two cases wooden braces are used.
In three cases strap-iron braces are used.
In one case strap-iron braces were galvanized.
In two cases 1¾ by 1¾ angle-iron braces were used
In two cases no braces were used.
In seven cases bolts were used to fasten cross-arms to poles.
In one case bolts were galvanized.
In two cases lags were used, average ⅝ to ¾ in. diameter.
Gains ⅝ to 1½ in. deep.

Class D.

In two cases strap-iron braces were used.
In one case no braces were used.
In two cases through bolts were used to fasten cross-arms to poles.
In one case ½ in. lag screws were used to fasten cross-arms to poles.
Gains ¾ in. to 1 in. deep.

Class E.

In three cases strap-iron braces were used.
In one case only one brace used on each cross-arm.
In one case strap braces were galvanized.
In one case angle-iron brace on one side of cross-arm.
In three cases ¾ in. through bolts were used.
In one case lags screws were used.
Gains ½ in. to 2 in. deep.

Class F.

In three cases no bracing done.
In one case white oak 3 by ¾ in. was used.
In one case cross-arms were mortised through pole.
In one case two ⅝ in. bolts were used.
In one case two ⅝ in. lags screws were used.
Gains 1½ in. deep.

(See sketches showing various arrangements of conductors on cross-arms, p. 691-694.)

37. *In crossing other power lines, telegraph or telephone lines, railroads or highways, are there any special precautions taken against the danger of the power lines breaking and falling? If so, what?*

VARIOUS METHODS OF CROSSING OTHER POWER LINES, TELEPHONE OR TELEGRAPH LINES, AND RAILROADS AND HIGHWAYS.

Class A.

1. Extra cross-arms and idle wires.
2. Double pole fixtures and short spans.
3. Guard wires underneath power wires.
4. Extra-high poles.
5. A ground net of ¼ in. steel cable suspended across railway right of way under power wires and six feet below them.

Class B.

1. A grounded network of iron wire under power line.
2. Extra-high poles.
3. Telegraph lines put under ground.

Class C.

1. Guard net under power wires.
2. Truss bridges built across railway track upon which power wires are supported.
3. Guard wires placed over telegraph wires.
4. High poles.

Class D.

1. Short spans and double fixtures.
2. High poles placed eight feet apart, telephone line passes between.
3. Bronze cables used over railway crossing.
4. Telegraph wires put in cable underneath.

Class E.

Guard wires.

Class F.

1. Twelve foot span and high poles.
2. Guard wires.
3. A grounded net made of ¾ in. steel cable suspended between poles over railway right-of-way about six feet under power wires.

40. *Are there automatic overload devices arranged for cutting off the individual sub-stations from the power line?*

The following automatic overload devices are used for cutting off the individual sub-stations from the power line:

Class A.

Four plants use high-tension fuses.
One plant uses high-tension fuse-switch operated by hand.
Two plants use automatic oil-switch.

Class B.

One plant uses high-tension fused cut-outs.
One plant uses fuse-switch.
One plant uses air-brake circuit-breakers.

Class C.

One plant uses fuse circuit-breaker.
One plant uses oil-switch.
One plant uses oil circuit-breaker.
One plant uses automatic circuit-breaker.

Class D.

None.

Class E.

One plant uses fuses.
Two plants use fuse-switch.

Class F.

Two plants use oil-switch.
Two plants use fuse.

41. *Are the intermediate sub-stations sources of much trouble? If so, what?*

VARIOUS SOURCES OF TROUBLE AT INTERMEDIATE SUB-STATIONS.

Class B.—One company had trouble with their rotaries but had cross-circuiting rings put between each armature section. O.K. now.

Class C.—One company had endless trouble with double-current generators; armatures burning out. One company has had trouble due to defective switching apparatus.

43. *How are the wires carried into the power house and into the sub-stations? (A sketch is desirable.)*
44. *How is the support arranged just outside of the building, and just inside of the building? (Sketch.)*

(See sketches showing various methods of bringing lines into power houses and sub-stations Figs. 2–15.)

45. *Do you have switches located outside to cut the wires entirely clear of the sub-stations?*

No. of plants that have switches located outside to cut the wires entirely clear of sub-stations.

Class	A	B	C	D	E	F
	8	0	3	0	1	1

II. CONDUCTORS.

47. *Of what material are they made?*
48. *Are they solid or stranded? If latter, how many strands or separate wires?*
49. *If of copper, are they hard drawn, medium drawn, or soft drawn?*
50. *Are they bare or insulated?*

KIND OF CONDUCTORS.

Class A.

Six plants use solid copper hard drawn.
Seven plants use solid copper medium drawn.
Four plants use solid copper soft drawn.
One plant uses 19-strand aluminum.
One plant uses 7-strand aluminum.
Twelve plants use bare conductors.
Seven plants use waterproof insulated conductors.

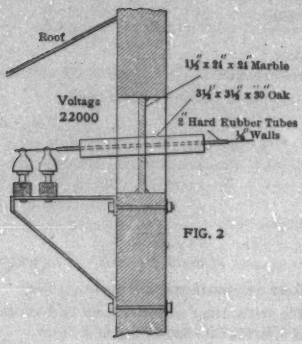


FIG. 2

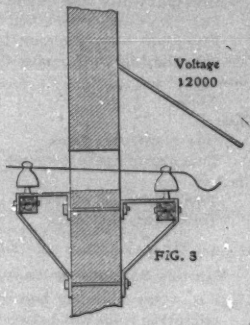


FIG. 3

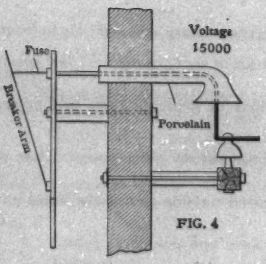


FIG. 4

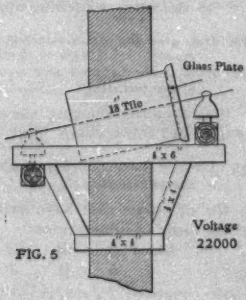


FIG. 5

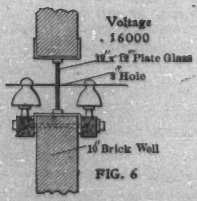


FIG. 6

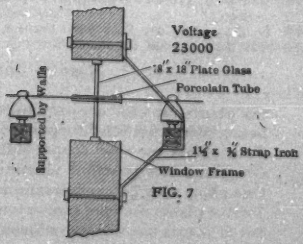


FIG. 7

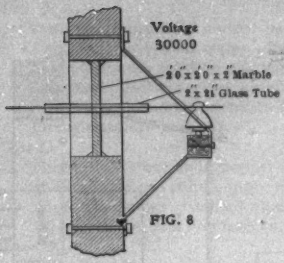


FIG. 8

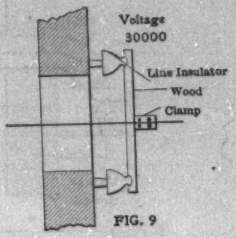


FIG. 9

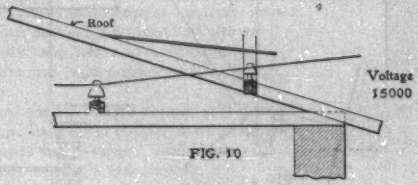


FIG. 10

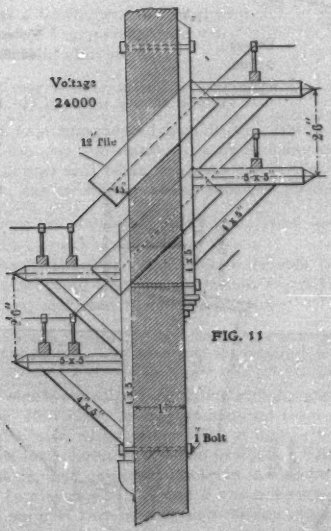


FIG. 11

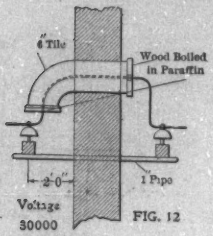


FIG. 12

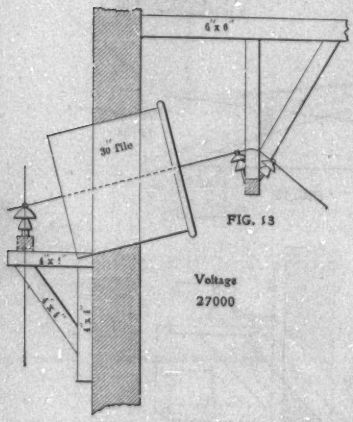


FIG. 13

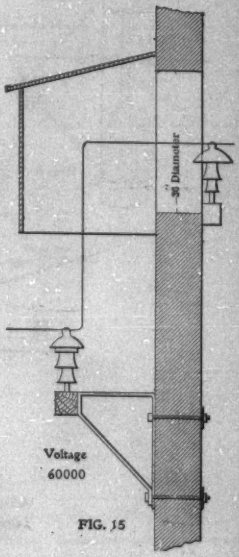


FIG. 15

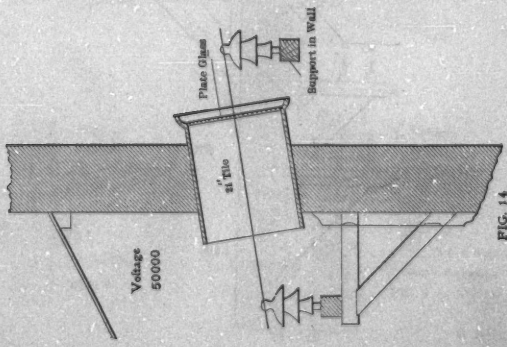


FIG. 14

Class B.

Two plants use solid copper hard drawn.
Two plants use solid copper medium drawn.
Two plants use solid copper soft drawn.
One plant uses stranded aluminum.
Five plants use bare conductors.
Two plants use waterproof insulated conductors.

Class C.

Three plants use solid copper hard drawn.
Three plants use solid copper medium drawn.
Three plants use stranded aluminum.
All plants use bare conductors.

Class D.

One plant uses solid copper hard drawn.
One plant uses solid copper medium drawn.
One plant uses solid copper soft drawn.
One plant uses 7-strand aluminum.
All plants use bare conductors.

Class E.

One plant uses 7-strand copper soft drawn.
One plant uses solid copper medium drawn.
Two plants use 7-strand aluminum.
All plants use bare conductors.

Class F

Two plants use solid copper medium drawn.
One plant uses solid copper hard drawn.
One plant uses solid aluminum.

51. *Have you had any serious amount of corrosion of conductors due to any causes? If so, what are the causes?*

Only two plants have experienced trouble with conductors corroding; viz., one company has one sub-station at a chloridizing quartz mill; the gases corrode the copper and cover the glass line-insulators with a film. The other company has its copper lines corroded by chemical fumes.

52. *If the conductors are aluminum, have you found them satisfactory? If not, why?*

One company experienced a great deal of trouble with their solid aluminum line; cause being that the aluminum crystalized due to the continuous vibration, and used to break frequently.

53. *Is high-tension wiring inside of buildings done with bare or insulated wire, and if the latter, what kind and thickness of insulation?*
54. *What kind of insulators are used for this interior wiring?*

The majority of plants use rubber-insulated wire for their interior wire (high tension) the thickness of rubber varying from $\frac{3}{32}$ in. to $\frac{1}{4}$ in. The balance use bare wire, with the exception of four or five plants which use paper or rubber lead-covered cable laid in ducts. The interior wiring in classes A and B is held on porcelain cleats and knobs in the majority of installations. In classes C, D, E, and F the ordinary line insulator is generally used to support the interior high-tension conductors.

III. LINE INSULATORS.

55. *Are the insulators glass or porcelain?*
56. *What is name of maker and what is the trade name or designation for them?*
57. *Have you any preference as to material and if so, why?*
58. *If porcelain, are they tinted, and what color?*
60. *Are the wires carried upon the top or the side of the insulators?*
61. *What tests were given the insulators before installing?*
62. *At what voltage will a flash occur between wire and pin when being sprayed with water?*
63. *At what voltage will they puncture?*
64. *Have you found your insulators satisfactory, if not what has been the trouble and to what has it been due?*

TABLE C.

Class.	Material.			Color.		Method of Tying.		Tests.		Makers.
	Porcelain.	Glass.	Porcelain and Glass.	White.	Brown.	Side of Insulator.	Top of Insulator.	Puncture Volts.	Spray Volts.	
A	6	9	3	7	2	6	11	20 000 to 50 000	—	R. Thomas & Son Co. Hemingray Glass Co. Imperial Porcelain Works. C. S. Knowles. P. Locke & Co. General Electric Co. Redlands Co. Guion, Italy.
B	2	4	1	3	1	4	2	40 000 to 50 000	25 000	
C	4	4	1	3	3	4	3	50 000 to 75 000	—	
D	2	2	—	1	1	2	1	80 000 to 120 000	—	
E	4	0	0	4	0	4	0	60 000 to 90 000	35 000 to 55 000	
F	2	1	1	1	1	1	1	120 000 saltwater	70 000	

Notes.—Prefer porcelain to glass on account of greater mechanical strength; greater dielectric strength; less liability to creeping of static over surface.

Prefer glass to porcelain on account of defects being easier detected by inspection; less tendency for dirt to hold on.

Four companies had trouble with tops breaking off glass insulators at grooves, due to changes in weather, etc. Two companies had trouble with glazed filled insulators, the insulator cracking at the joints.

One company had trouble with film forming on glass insulator from quartz mill.

IV. CROSS-ARMS.

65. *What are the dimensions of the cross-arms?*
66. *Of what material are they made?*

Sizes vary from 2¼ by 4¼ in. to 4½ by 9 in., the average section being 3¼ by 4¼ in.

The majority of plants use yellow pine, other woods used are: white pine, yellow fir, Oregon pine, spruce, Oregon fir, peroba, and cabreura, the last two being Brazilian woods.

67. *If of wood, have they been treated in any way? If so, in what way?*

The following are different methods of treating cross-arms:

(1) Painted with white lead.
(2) Painted with mineral red in oil.
(3) Painted two coats.
(4) Painted coal tar.
(5) Painted two coats metallic paint.
(6) Treated with carbolinium.
(7) Boiled in linseed oil two or three hours.
(8) Dipped in bitumen paint.
(9) Dipped in creosote.

V. POLES.

68. *What kind of poles? Steel or wood? If wood, what kind?*

Majority of plants use cedar poles. Other woods used are: chestnut juniper, cypress, red cedar, tamarack, Idaho cedar, spruce, and white cedar.

71. *What are the dimensions of the tops of the different lengths of poles, also the minimum diameter of the butts?*

Tops vary from 5 in. to 8 in. in diameter.
Butts vary from 9 in. to 24 in. in diameter.
Average top is 7 in.; average butt is 12 in.
} Poles vary from 25 ft. to 45 ft. long.

72. *How deep are the different lengths of poles set into the ground?*

Poles are placed in ground from 4 ft. to 8 ft. according to their length and condition of soil.

Poles were treated in the following ways:

74. *Are the poles treated in any way? If so, how? Are they painted?*

(1) Gains painted with metallic paint.
(2) Butts tarred.
(3) Poles painted.
(4) Butts painted.
(5) Tops painted.
(6) Butts treated with carbolinium.
(7) Tops painted with linseed oil.
(8) Butts burnt and tarred.
(9) Butts painted with asphaltum.

75. *How are the tops finished?*

Majority of plants roof the tops of the poles.
A large percentage painted tops of the poles.

One plant puts cast-iron caps on poles.

One plant champfers the pole tops to pin that is in end of pole, and binds No. 6 galvanized-iron wire around end, and paints top with P. & B. paint.

76. *Is there a pin in the top of the pole, and if so, is there a metal band around the top?*

Four companies that have pin in top of the pole have an iron ring around pole.

One company uses a composite pole made with a 7-in. iron pipe, socket 13 ft. long, Australian jarra wood top 7 by 7 in., 17 ft. long, pressed into the socket; this pole is placed 6 ft. in the ground. Poles are tarred, and a galvanized-iron cap is put on top of pole. A few companies use octagonal and square poles.

Kind of Wood.	Location.	Life of pole in years.
Red Cedar	Ohio	20
Cedar	Oregon	10–15
"	California	10–15
"	Idaho	15
"	Montana	6–7
"	Washington	10–15
"	Minnesota	14–16
"	Pennsylvania	9
"	Canada	15
Chestnut	New York	8–14
"	Pennsylvania	8
"	Massachusetts	8–12
" (2d growth)	Pennsylvania	12–16
Juniper	Georgia	15
Cypress	Carolina	8
Tamarack	California	5
Pine	Pennsylvania	8

69. *What is the length of their life and on what peculiar conditions, if any, does this depend?*

78. *Give dimension sketches of pole-head, showing cross-arms, pins, and insulators.*

See dimension sketches on pages 691-694.

73. *Are any of the poles set in concrete or otherwise, giving additional solidity in the earth?*

The following methods are used for poles in boggy or swamp land:

1. Set in concrete.
2. Tamped with broken stone.
3. Protected by rock cribs.

VI. PINS.

79. *Of what material are the pins made?*
80. *If of wood, what kind of wood?*

Classes A, B, C, and D.

In these classes the standard 1½ locust pin is used in most cases; other kinds of pins used are: black locust, oak, eucalyptus, hickory, iron with wooden thimbles, porcelain, and iron ⅝ in. fastened into insulators with cement.

Classes E and F.

Following kinds of pins are used:

1. Iron pins held into insulator with Portland cement.
2. Iron pins, wooden thimble, porcelain base.
3. Locust and eucalyptus.
4. Steel pin and cast-iron bushing in cross-arm (see sketch).

81. *Are they treated, and if so, how?*

Pins are treated in the following ways:

1. Boiled in paraffin about 24 hours.
2. Boiled in linseed oil about two hours.
3. Painted.
4. Dipped in elastic bitumen.

In a great many cases pins were not treated in any way.

In all cases where wood pins were used they were boiled in paraffin for 24 hours.

83. *Are the pins fastened in the cross-arm and pole, and if so, how?*

Pins are fastened to cross-arms in the following ways:

1. Nailed (in most cases).
2. Nut and washer (when iron pins are used).
3. Wooden dowel (in one case).
4. Iron spring (in one case).
5. Driven into cross-arm tightly.

The following methods are used to hold pins in cross-arms and poles:

1. Pins screwed into top of pole.
2. Nut and washer (iron pins).
3. Nailed through cross-arm.
4. ½ in. and ¾ in. oak dowel.

82. *What are the dimensions of the pin?* (*A sketch is desirable.*)

See sketches showing various size pins, Figs. 16-21

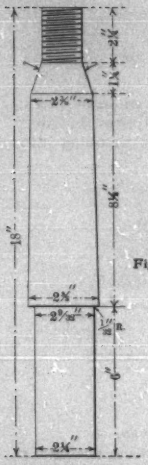
VII. TELEPHONE LINE.

85. *Have you telephone lines upon your transmission poles?*

All plants with the exception of four have telephone lines on same poles as the power lines. One plant in Class F has its telephone line on separate poles 200 feet from the power line.

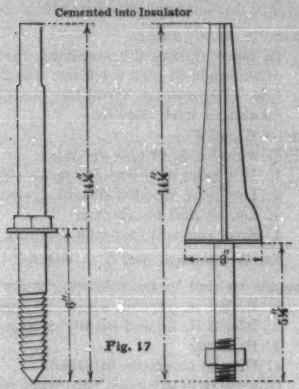
87. *What kind of pins, insulators, and cross-arms or brackets are used?*

Majority of plants use standard side brackets, cross-arms, pins, and glass telephone insulators.



27000 Volt Pin

Fig. 16

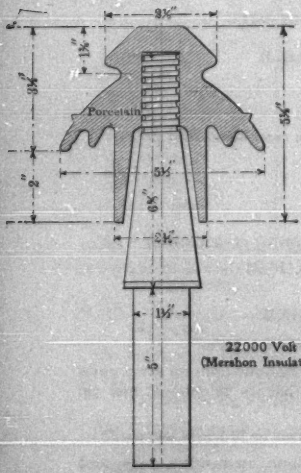


Top Pin

Cross Arm Pin

50000 Volt Iron Pin

Fig. 17



22000 Volt
(Mershon Insulator)

FIG. 19

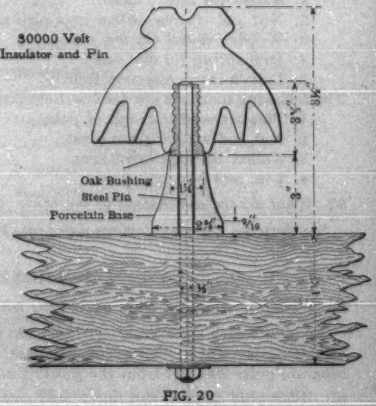


FIG. 20

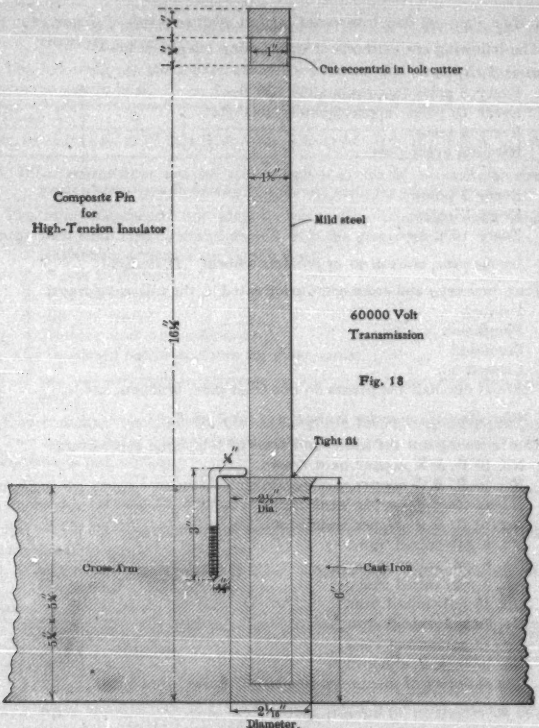
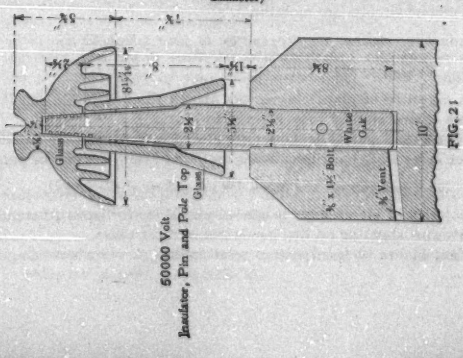


Fig. 18



60000 Volt Insulator, Pin and Pole Top

FIG. 21

86. *How often are they transposed, and at what intervals of distance?*

The following are methods of transposing telephone lines:

Classes A, B, C, D.

Every 5 poles (approximately 500 feet).
Every 10 poles (approximately 1000 feet).
Every 4 poles.
Between every pole.

Classes E, F.

Every 2 poles.
Every 3 poles.
Every 1600 feet.

88. *Are the pins, cross-arms or brackets treated? If so, how?*

Pins, brackets, and cross-arms are treated in the following ways:

Painted.
Paraffined.
Creosoted.
Linseed oil.
About one-half the plants do not treat pins, brackets, etc.

89. *What kind of conductor is used, and what size?*

The following are the kinds and sizes of telephone conductors:

No. 10 B. & S. copper hard drawn.
No. 10 B. & S. copper medium drawn.
No. 12 B. & S. copper hard drawn.
No. 10 B. & S. copper waterproof.
No. 6 galvanized iron.
No. 8 galvanized iron.
No. 9 galvanized iron.
No. 10 galvanized iron.
No. 12 galvanized iron.
No. 12 galvanized steel.
No. 10 B. & S. aluminum.

The majority of plants use No. 10 galvanized-iron wire.

90. *Is the circuit an all metallic one?*

All telephone circuits are metallic.

91. *Do you have stations for tapping on to your telephone line or do your inspectors attach their portable telephone to the line wherever they may happen to be?*

In the majority of plants inspectors attach their portable telephones to the line wherever they may happen to be.

In one case stationary telephones are placed in booths every two miles.

In three cases stationary telephones are placed in boxes on the poles.

92. *If so, what precautions are taken for the safety of the users?*

The majority of plants have insulated platforms for users to stand on, these platforms standing on line insulators in most cases.

One plant makes their inspectors wear rubber gloves when using telephone.

93. *What is the normal distance between the nearest power wires and the telephone wires?*

The following are the maximum and minimum distances of telephone line from power lines:

Class A	B	C	D	E	F
2 ft. to 15 ft.	4 ft. to 10 ft.	4 ft. to 10 ft.	3 ft. to 6 ft.	4 ft. to 8 ft.	5 ft. to 8 ft.

96. *What means have you for the protection of the telephones, and those using them, from lightning and crosses with the power wires?*

The following means are used for protecting telephones and those using them from lightning and crosses with the power wires:

1. Lightning-arresters (in most cases).
2. Fuses to ground.
3. Film cut-outs.
4. Barbed wire.
5. Rubber hose on receiver cord.
6. Insulated stools or floors (in most cases).

97. *If you use telegraph instruments instead of telephone, state the reason why?*

One company (in Class F) uses a telegraph instrument for signaling. Two other plants use telegraph instruments, one of them only when telephone is not working.

98. *Show on sketch, position of telephone wires with reference to power wires, showing the normal distance apart of the telephone wires?*

See sketch showing position of telephone wires relative to power wires, pages 691-694.

99. *What is the e.m.f., induced or other, between your telephone wires and the ground?*

Classes A, B, C, D.

Highest e.m.f. recorded between telephone wire and ground is from 20 to 130 volts.

Classes E, F.

In these classes highest e.m.f. was 3000 volts. A great many plants claim there is no e.m.f. between telephone wires and ground, due to: careful transposing; using good insulators and careful wiring; a reactive coil in line with middle point grounded.

VIII. TRANSFORMERS.

101. *What is the capacity of your transformer units in the power-house and sub-stations?*

Class A.

Transformer units at power-house range from 125 to 225 kw.; at sub-station from 7.5 to 375 kw.

Class B.

Transformer units at power-house range from 150 to 500 kw.; at sub-station from 75 to 300 kw.

Class C.

Transformer units at power-house range from 175 to 1400 kw.; at sub-station from 20 to 2250 kw.

Class D.

Transformer units at power-house range from 225 to 500 kw.; at sub-station from 125 to 350 kw.

Class E.

Transformer units at power-house range from 289 kw.; at sub-station from 150 to 500 kw.

Class F.

Transformer units at power-house range from 1000 kw.; at sub-station from 333 to 1000 kw.

102. *Are the transformers connected in* Δ *or Y?*

The following are the various methods of connecting transformers:

1. Δ (used in most cases).
2. Y.
3. Δ and Y.
4. Scott (used in a great many plants).
5. Single phase.

103. *Is the same connection used on both primary and secondary sides?*

In the majority of plants the same transformer connections are used on both primary and secondary sides.

104. *Is the neutral grounded upon either the high or low voltage side? If so, why? If not, why not?*

In the majority of plants the neutral is not grounded at all.

105. *Do you know any marked advantages or disadvantages in grounding the neutral? If so, state them.*

The advantages of grounding neutral are:

1. To prevent high-tension from doing damage to low-tension network, should insulation between primary and secondary break down.
2. Reduces strain on transformer and line under normal conditions.
3. Prevents accumulation.

In one plant neutral is grounded on high-tension side. The reasons for it; less expense in transformer construction; greater safety in insulation of windings; greater flexibility of general system in case of loss of transformers, or one wire of the circuit, or anything which cripples any one part of the three which go to make up the system, we can still operate on two until we can change to the other line and repair it, and have no interference with service. Greater simplicity in wiring of stations; less interference with telephone wires and outside circuits, and we believe, less opportunity for resonance and other serious line effects. At least, we have never had any of these effects.

Disadvantages are:

1. Increases danger of accident to apparatus.
2. Double-current generator is short circuited if neutral of secondary is grounded.
3. Liable to damage telephone system if power line should become grounded or open.
4. Increases liability to side flash from lightning

106. *Is there a spark-gap connection to earth from the centres of either the high- or the low-voltage coils?*

About two-thirds of the plants do not have spark-gap connections to earth from the centre of either the high- or the low-tension coils.

107. *Have the transformers ground-shields between the high- and low-tension windings?*

Only three plants have ground-shields between the high- and low-tension windings of their transformers, but majority of plants have their transformer cases grounded thoroughly.

108. *Are the transformers oil-insulated or dry?*
109. *Are they air-blast, water-cooled, or natural-cooled?*
110. *What is the voltage of the low-tension side?*

TABLE D.

Class	Oil-insulated natural-cooled	Oil-insulated water-cooled	Oil-insulated air-blast cooled	Dry air-blast cooled	Range of voltage on low-tension side.
A	11	3	1	5	360 to 2300
B	4	2	1	0	350 to 2400
C	6	2	1	1	390 to 2400
D	1	3	0	2	2200 to 2300
E	2	1	0	2	750 to 2400
F	1	4	0	0	1500 to 4000

111. *Is there transformation of phase as well as of voltage?*

Only about 6% of the plants transform the phase of the current.

112. *Have you had any trouble with your transformers? If so, what?*

The following troubles with transformers have been experienced:

1. Terminals being improperly soldered.
2. Transformer burnt out, cause being: not dried out enough before being put into service.
3. Breakdown between primary and secondary coils, bad insulation being the cause.
4. Breakdown from lack of proper circulating ducts between coils and from canvas hoods over ends of coils, making dead places for oil, oil would heat and burn.
5. Burnout from lightning discharges.
6. Burnout from overloading.
7. Burnout from defective leads.
8. In one plant six natural-cooled oil-filled transformers furnished with the first contract were absolute failures; had to be re-

designed; since, have been all right. Thirty air-blast transformers have never caused one dollar for repairs in five years—with one exception, which was due to an attendant not noticing that a terminal had become unsoldered where two banks were operating in parallel, and its mate was burned out after carrying overload of 100% for at least 15 days.

IX. LIGHTNING PROTECTION.

113. *What devices are used to protect your power lines from lightning? Lightning-arresters, grounded wires, or both?*

With the exception of one plant which uses barbed wire, lightning-arresters are used; four plants use both lightning-arresters and ground-wire.

115. *Are the wires smooth or barbed and of what material?*
117. *How are they fastened to poles or cross-arms; on insulators? If on insulators, why?*

Barbed wire is generally used in preference to smooth wire. Some plants run taps to ground at every pole, some at only every four poles, and some at only every half mile. For mechanical reasons this ground-wire is generally run on insulators; but in some cases it is fastened to pole or cross-arms with staples.

118. *How is the ground made?*

The following are various methods of grounding this ground wire:

1. Twisting around butt of pole.
2. Gas-pipe driven into ground 6 ft. to 10 ft., the wire put into pipe and pipe filled with about 4 in. of lead.
3. Galvanized-iron plates placed in ground.

119. *Do you consider grounded wires as a valuable protection?*
120. *Do you consider them more or less desirable than any other means of lightning protection?*

Only nine companies consider grounded wires a valuable protection; as a rule they are thought less desirable than other lightning protection.

121. *If lightning-arresters are used, do you consider that they furnish any protection against rise of voltage, due to any disturbance upon the system, such as the throwing on or off of all or part of the load, etc.*

The majority of plants consider lightning-arresters furnish protection against rise of voltage due to any disturbance upon the system such as the throwing on or off of all or part of the load, but a number of plants think that for a moderate rise in voltage they furnish no protection.

122. *Do you consider them a complete protection against such rise?*

The majority of plants do not think lightning-arresters are a complete protection against such rises.

123. *What kind of lightning-arresters are used?*

The following makes of lightning-arresters are used (in order of the quantity):

General Elec. Co. (Wirts).
Westinghouse Elec. Mfg. Co. (low equivalent).
Stanley Mfg. Co.

124. *Do you have banks of lightning-arresters along your line? If so, at what intervals?*

Lightning-arresters are placed in the following ways along the line:

1. At power-house and sub-stations only.
2. At each end and middle point of line.
3. At points dividing line into four equal parts.
4. At irregular intervals (at cable terminals, etc.).

125. *Are they necessarily at sub-stations?*

The greater number of plants consider it necessary to have lightning-arresters at sub-stations.

127. *Is there resistance in series or in parallel with the arresters? If so, what kind of resistance (such as carbon, metal, water, etc.)?*

Lightning-arresters have the following kind of resistances in series or parallel, or both:

Carbon resistance in series.
Graphite rods in series.
German silver in series.
German silver in series and parallel.

128. *Is there capacity or inductance in series or in parallel, with the arresters or line?*

Majority of plants have choke-coils in series with line.

129. *Do you find that the lightning-arresters do their work satisfactorily? If not, wherein do they fail?*

Majority of plants consider that lightning-arresters do their work satisfactorily, but some plants experience the following troubles:

1. Generator current follows a discharge to ground.
2. Lightning jumps to water coil on transformers.
3. Arrester put out of order after each discharge.
4. When switching high-tension circuits, generator current follows discharge to ground.

130. *How are the grounds made for your lightning-arresters?*

The following methods are used for grounding lightning-arresters:

1. Copper plate about 30 in. sq. placed below water level in river bank; two strands of No. 4 copper wire attached to different points of plate by solder, plate is then covered with about 12 in. of coke or fine charcoal and then rest of hole filled with damp earth. In some cases plate is kept wet by means of a water-pipe.
2. Galvanized-iron pipe driven into ground about 18 feet.
3. Coils of copper wire buried in bank of river below water line.
4. Connected to steel flumes, steel structure, or feed-water pipe.
5. Connected to rails in cases of electric railway.
6. Connected to negative bus-bars.

X. CABLES.

131. *Have you any cables included in your transmission line?*

Only eight plants have cables in their transmission lines.

133. *Are they lead covered?*
136. *Do you prefer rubber or paper insulation, and why?*

All cables used are lead-covered. One plant in Class A has a three-phase submarine cable 4300 feet long, steel armored.

In most cases where cables have been installed recently paper insulation is used; the advantages claimed for paper insulated cables are:

Cheaper and more durable: rubber insulation deteriorates in short time. One plant claims that there is less trouble from moisture with rubber.

137. *Give sketch of section of cable, showing arrangement and size of conductors and arrangement and thickness of insulation and sheath?*

(Sketches of various cables used are shown, see Figs. 22-25.)

138. *Are the conductors solid or stranded?*

Stranded cable is used almost entirely.

139. *Is the sheath lead or lead and tin and is it iron armored?*
140. *If lead and tin, what is the percentage of the latter?*

Cables in most cases are covered with a composition of lead and 3% of tin—the tin lessens corrosion.

143. *What means do you employ to protect cable sheaths from electrolysis?*

The cable sheaths are grounded to rails, gas-pipes, etc. as a protection against electrolysis.

144. *What protective devices have you for the cables, and do they prove effective and satisfactory?*

The majority of plants have lightning-arresters as a protection for their cables, also overload circuit-breakers in stations.

145. *Do you take any unusual precautions in operating to ensure the safety of your transmission cables?*

In most cases no unusual precautions are employed in operating to ensure the safety of transmission cables.

146. *What kinds of ducts do you employ for carrying your cables?*

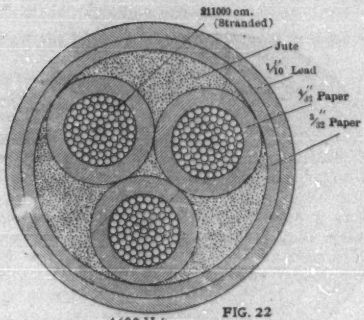
The following are different kinds of ducts used for carrying cables:

Vitrified clay.
Cement-lined vitrified clay.
Creosoted wooden boxes.
Iron pipes (when cables run under water).

XI. OPERATION.

147. *Do you do your switching on the high- or the low-tension side of the transformers?*
148. *If the former, do you switch circuits when there is voltage on them but no current?*
149. *Do you switch high-tension circuits when loaded?*

Sixty-five per cent. of the plants do their switching both on low- and high-tension sides. In classes A and B in a great many plants switching is done on low-tension side only. In Class A, 50% of the plants do their switching on high-tension side only. The majority of plants make it a practice to switch their high-tension circuit with volt-



4500 Volts FIG. 22

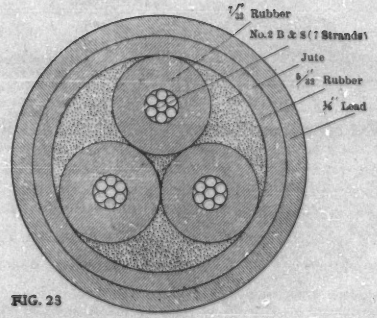


FIG. 23

25000 Volts

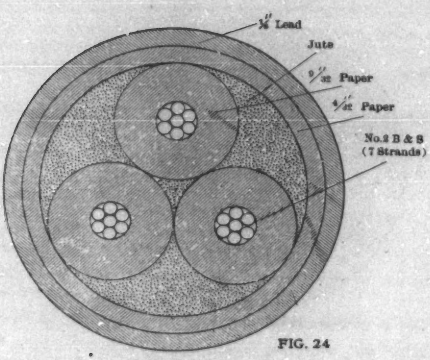


FIG. 24

25000 Volts

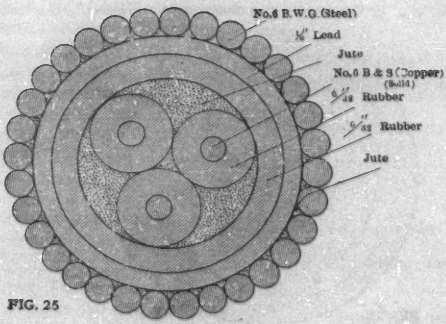


FIG. 25

12000 Volts Submarine

age on them, but no current. A number of plants, probably 40%, switch their high-tension circuits when loaded, and about 10% will do it only when it is absolutely necessary.

150. *What means for high-tension switching do you have?*

Following are the high-tension switches used in order of the quantity in use:

Oil-switches.
Fused-switches.
Air-switches.
Knife-switches (quick break).

Ram's horn: the horn is of ½-in. brass rod, curved and converging to a gap of about 10 in. In stations where there is any large amount of synchronous apparatus, this gap is spanned by a solid ½-in. rod set into suitable clips on the horns and provided with a suitable operating handle. In simple transformer stations the gap is spanned by a 1-in. porcelain rod having brass contact-pieces with binding screws for ordinary fuse-wire. These switches have been operated successfully on loads as large as 3000 kw.

151. *Is it satisfactory? If not, why?*

All plants claim their way of switching is satisfactory.

152. *Do you have high-tension fuses, and if so, what type?*

The following kinds of high-tension fuses are in use:

Ball type.
Pole type.
Expulsion fuse.
D. & W. powder fuse.
Porcelain enclosed.
Glass enclosed.
Expulsion aluminum.
Sach's Noark.

154. *When you open a loaded high-tension main circuit with an air-break switch, do the lightning-arresters discharge?*

155. *If instead of an air-break switch an oil-break switch is used, does it have the same effect?*

In classes A, B and C when loaded high-tension main circuits are opened with air-break switch, the lightning-arresters *do not* arc, but in classes D, E and F they generally *do* discharge. But plants using oil-switches are not troubled to the same extent with their lightning-arresters discharging when they open a loaded high-tension main.

156. *Do you operate with grounded neutral? If so, why? If not, why not?*

A very small percentage of the plants operate with neutrals grounded.

157. *Have you ever had any trouble due to operating with grounded neutral either in your power circuits or because of trouble with neighboring power, telephone, or telegraph circuits?*

Yes; a number of plants operating with ground neutrals affected telephone and telegraph circuits in the neighborhood. One company says if all the power of one of the large power stations be transmitted over

the whole length of the circuit with one wire of the transmission line open the telegraph companies are affected, but as this never occurred but for an instant once or twice it is not serious. We can still talk on our own telephone line with the sub-station carrying 500 kw., working with two transformers as above mentioned, and affect no neighboring power circuits, nor does it affect our own circuit on neighboring poles when running separate.

158. *Have you ever had one power-wire broken or one leg of the circuit open under a heavy load when the neutral was grounded?*
159. *Did this cause damage or trouble in any of your circuits or in other circuits, near or remote? If so, what?*

A few plants have had one power-wire broken or one leg of circuit open under a heavy load when the neutral was grounded, but in most cases no damage was done.

160. *Have you ever had trouble from the burning or charring of pins, cross-arms or poles due to the high-tension current?*
166. *What means have you taken to remedy the trouble and have the means proved effective?*

A great many plants have had trouble with burning of pins, cross-arms, or poles. In most cases this was due to continuous discharges, caused by:

1. Pin or insulator breaking; generally remedied by replacing pin or insulator.
2. Spray from falls freezing on insulator; remedied by moving line further from falls discharging across insulator.
3. Bad insulator starting leaking to ground wire; remedied by moving ground wire from face of cross-arm.
4. Insulator with iron pin cracking and burning arm.
5. Pins burn, due to rain; remedied by replacing porcelain insulator with glass. In some cases discharge appeared to come from inner petticoat, in others through the porcelain and burning pin ½ in. from top.
6. Poor porcelain; remedied by replacing untreated oak pins with locust pins that have been boiled in paraffin and painted with P. & B. paint; also painted thread of insulator.
7. Gases from quartz mill forming film over surface of insulator.
8. Soot from passing trains being deposited on insulators; remedied by cleaning insulators and replacing pins.

In most cases discharge was worse in wet and foggy weather, and in many cases discharge took place in wet weather only.

167. *Have you had any trouble from insulators puncturing or current flashing around them?*

Only about 6% of the plants have had trouble from insulators puncturing or current flashing round.

168. *If the latter, what was the cause?*

The cause being either insulators damaged by stones or defective porcelain or glass, more often the latter.

169. *Do you have many insulators maliciously broken?*
170. *If so, what means have you taken to stop this, and with what success?*

A great many plants experience trouble from having their line insu-

lators maliciously broken. The following means have been taken to stop this:

1. By posting warnings.
2. Offering rewards for evidence that will enable them to locate and convict guilty persons.
3. Having watchmen along line.
4. Arrest and fining.

(Not much success with any of above methods.)

171. *Have you had any insulators break from internal strains when on the line?*
172. *Was this from actual strains in the glass or from improper placing upon the pin?*

Only a few plants have had insulators break from internal strains when on the line, the cause in most cases being the improper placing of insulator on pins.

173. *Have you ever had arcs start between your line wires?*
175. *Are you troubled from short circuits upon your lines? If so, what are the most serious causes?*

The following are causes for arcs being started between lines:

1. A piece of wire maliciously thrown across lines.
2. Branches of trees falling across lines.
3. High winds blowing wires together.
4. Large birds coming in contact with lines.
5. Broken insulators and pins.
6. Sleet storms.
7. Lightning discharges.
8. Generators ran away, due to sudden change in load.
9. Fields of generators demagnetized owing to armature reaction.

176. *Is your telephone system satisfactory?*
178. *Is there much more noise with a heavy current in the power-line than with a light current?*

Most plants claim that their telephones work satisfactorily; but a great number of plants complain that their telephones are more or less noisy in wet weather. One or two plants claim that telephones work better in wet weather, one of these plants belong to Class F.

Majority of plants claim that the amount of current in power-line does not affect their telephones. One plant says the heavier the load the less the noise in the telephones.

179. *Have you ever had any one hurt from the power voltage when using the telephone? If so, how did it happen?*

Only one accident recorded in connection with telephone; superintendent of power-house was killed at telephone. They think heavy sleet on power-wire made it sag until it touched telephone wire.

181. *Do you do work upon dead circuits when other circuits on the same pole-line are alive? If so, what precautions do you take?*
182. *Are such repairs made only in dry weather and in the daytime, or are they made at any time?*

Majority of plants do work upon dead circuits when other circuits on the same pole-line are live; the following precautions are taken:

1. Ground dead circuits.

2. Short circuit dead circuits.
3. Both ground and short circuit dead circuits.

In classes A and B where circuits are close together on cross-arms all circuits on same side of pole as dead circuit are made dead.

Majority of plants repair their lines at any time, day or night.

183. *How do you have your circuits patrolled and how often?*
184. *How much distance is one man able to patrol satisfactorily and over what kind of country?*

Lines are patrolled at different intervals of time ranging from once a day to five or six times a year, according to the kind of country passed through. Lines running by railway are often patrolled by men on a hand-car, lines cross-country by men on foot and on horseback. The amount of line that a man can patrol in one day varies with the kind of country: on level country ten miles; on hilly country from three to six miles. A man on horseback can do about 30 miles on level or about eight miles in mountainous country.

One company has a lineman and helper to look after 30 miles of line; they patrol line twice a week.

Another company have three men on hand-car who patrol 30 miles a day.

A number of plants do not have their lines patrolled regularly, but only when trouble occurs.

185. *What means are taken to compensate for capacity charging current of transmission lines?*

No special means are taken to compensate for capacity charging current of transmission lines by plants.

186. *Is voltage drop compensated for at receiving stations? If so, how?*
187. *Where there is more than one receiving station, what means, if any, are used for independently regulating the voltage desired by these stations?*

The various methods are used for compensating voltage drop at receiving stations:

A number of taps on transformers.
Regulators on secondary side of transformers.
Regulating heads on transformers.
Motor-driven potential regulators
Rotaries over-compounded.
Synchronous motors.

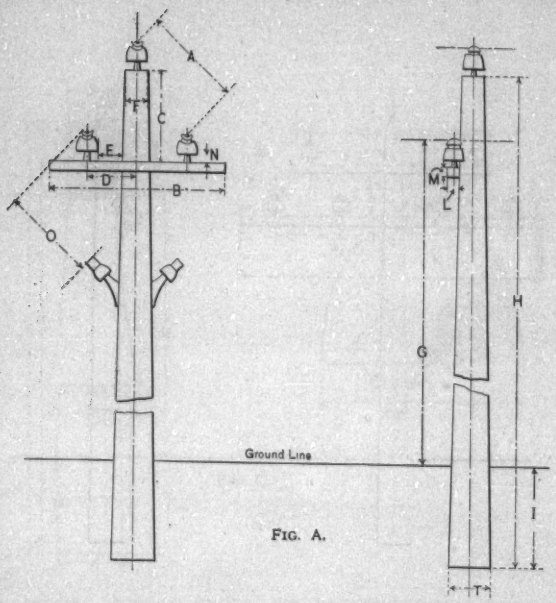


FIG. A.

Voltage.	A	B	C	D	E	F	G
16 000	18″	24″	16″	9″	—	6″	—
22 000	30″	68″	24″	15″	—	—	27′
22 000	30″	42″	26″	15″	8″	7″	15′
27 000	48″	64″	42″	24″	11″	12″	35′
30 000	40″	60″	23″	20″	12″	7″	20′2″
40 000	108″	120″	84″	54″	43½″	7″	19′6″
50 000	60″	72″	52″	30″	20½″	7″	26′6″
50 000	78″	96″	67½″	39″	29″	10″	23′6″
45 000	42″	50″	36½″	21″	10″	8″	27′8″

Voltage.	H	I	J	K	L	M	N	O
16 000	30′	5′	10″	—	4″	5″	2½″	48″
22 000	35′	6′	—	—	4″	4″	3″	120″
22 000	25′	4′	—	—	3½″	4½″	—	60″
27 000	45′	7′	17″	—	6″	6″	—	72″
30 000	22′3″	6′	—	—	3½″	4½″	—	72″
40 000	35′	5′6″	16″	—	5½″	3½″	10″	—
50 000	35′	5′6″	—	—	4½″	4½″	2½″	60″
50 000	35′	6′	14″	—	3½″	5½″	1½″	72″
45 000	35′	5′6″	12″	—	5½″	5½″	2½″	90″

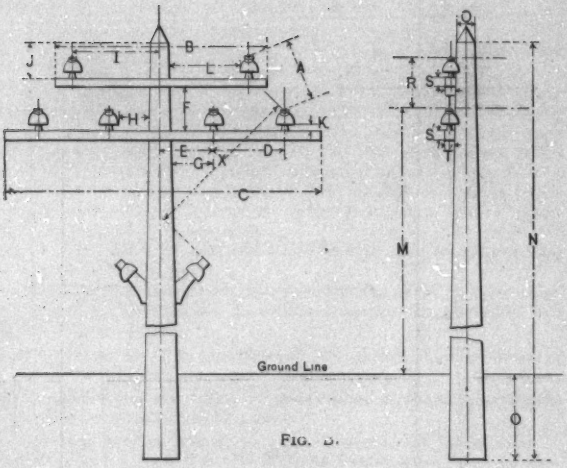
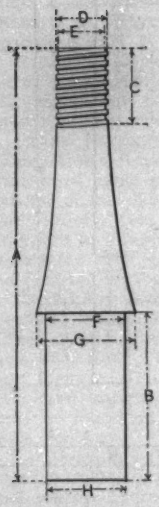


FIG. 5.

Voltage.	A	B	C	D	E	F	G	H	I	J	K
12 000	24″	54″	72″	18″	14″	17½″	—	8″	23″	—	3″
11 000	20″	54″	72″	20″	12″	16½″	8″	8″	22″	8″	4″
11 500	24″	60″	84″	24″	12″	20½″	9″	9″	24″	5″	2″
23 000	30″	72″	102″	30″	15″	26½″	—	8″	30″	8″	24″
25 000	18″	60″	86″	24″	—	—	—	8″	22″	—	—
34 000	25½	62″	80″	18″	18″	20″	14″	—	27″	8″	3″
30 000	30″	78″	108″	30″	18″	22″	9″	6″	33″	8″	4″.

Voltage.	L	M	N	O	P	Q	R	S	T	S′	T′	X
12 000	17″	21′	30′	6′	—	—	22″	4½″	3½″	4½	3½	72″
11 000	—	—	35′	5′	18″	7″	—	4½	5½″	4	5	96″
11 500	18″	—	24′	4′	—	6″	20½″	4½″	3½″	4½	3½	—
23 000	23″	23′	30′	5′	12″	7″	—	4½″	3½″	4½	3½	48″
25 000	—	30′	36′	6′	14″	7″	—	5½	4½	5	4	72″
34 000	19½″	—	35′	5′	12″	8″	24″	3½″	2½″	4½	3½	66″
30 000	24″	27′	36′	6′	16″	10″	26″	5½	4½	5	4	48″



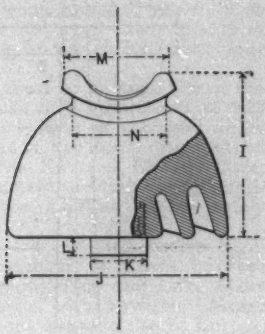


FIG. C.

Voltage.	A	B	C	D	E	F	G
12 000	11″	4½″	2″	1″	½″	1½″	2″
4 600	9″	4″	2″	1″	½″	1½″	1½″
11 500	8½″	4″	2½″	1″	13/16″	1 7/16″	1 11/16
12 000	9″	4″	2″	1″	½″	1½″	2½″
16 000	10½″	4½″	2″	1″	½″	1½″	1½″
20 000	10″	4½″	2½″	1″	½″	1½″	1½″
25 000	12″	4″	2½″	1½″	½″	1½″	
30 000	10″	4½″	2½″	1″	½″	1 9/16″	2″
50 000	18½″	4½″	3½″	1″	13/16″	2 7/16″	2 15/16″

Voltage.	H	I	J	K	L	M	N
12 000	1½	4″	5″	2½″	½″	2½″	2½″
4 600	1½	—	—	—	—	—	—
11 500	1½	4½″	5½″	2″	—	3½″	2 3/16″
12 000	1½	4½″	6″	1 5/16	3/16″	2½″	3″
16 000	1 15/32	4½″	6″	—	—	3″	—
20 000	1½	4″	5½″	2½″	1½″	2½″	2½″
25 000	1½	—	—	—	—	—	—
30 000	1½	5″	7″	2½″	—	3½″	2½″
50 000	2 7/16	9″	10″	4½″	3½″	4½″	3½″

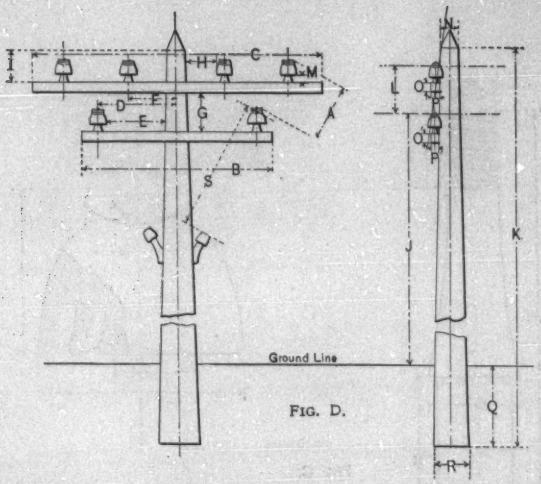


FIG. D.

Voltage.	A	B	C	D	E	F	G	H	I	J
12 000	24″	84″	84″	24″	17″	12″	16½″	5″	4′	32′
12 000	30″	72″	96″	20″	—	14″	21″	—	—	22′
15 000	30″	61″	96″	20½″	—	9″	27″	—	6′	32′
22 000	30″	68″	99″	—	30″	15″	24″	15″	9′	27′
24 000	36″	96″	132″	36″	—	18″	25½″	—	24″	25′

Voltage.	K	L	M	N	O	P	O′	P′	Q	R	S
12 000	39′8″	21″	3″	8″	4½″	3½″	4½	3½	6′	16″	54″
12 000	30′	26″	—	6″	4½″	4½″	4½	4½	5′	—	—
15 000	40′	31½″	—	7″	4½″	3½″	4½	3½	6′	16″	10′
22 000	35′	30″	—	6″	4″	4″	4	4	6′	—	120″
24 000	35′	31½″	—	8″	5½″	5½″	5½	5½	6′	14″	30″

For the Committee on High-Tension Transmission.

RALPH D. MERSHON,
Chairman.

DISCUSSION ON HIGH-TENSION TRANSMISSION REPORT.

J. H. FINNEY: Is not the spacing between wires given in Class E, in error? In the other classes the spacing seems to increase in direct ratio, but in Class E, for 31 300 volts, the spacing is only 31 inches. Is not this a mistake?

RALPH D. MERSHON: The figures were examined carefully so as to prevent mistakes. There are not very many plants in this class, only four; so it depended on the choice of only four men to decide the average.

PETER JUNKERSFELD: Answer 5, Class A, on page 666 of the Committee's Report refers to the use of a ground-net of 0.25 inch steel cable suspended across the right of way and under power wires. This is of interest as it has been proposed by the Underwriters for insertion in the National Electric Code. It would be interesting to know the extent to which such ground-nets have been used and what degree of protection can safely be credited to them.

PRESIDENT ARNOLD: These nets are installed under high-pressure transmission lines in a number of places between Chicago and New York on lines parallelling the Lake Shore and the New York Central railroads, also between Chicago and Denver. They are in much more common use in Europe. We have just begun to use them; as a particular instance they may be found on the line of the Fonda, Johnstown, & Gloversville Railway.

L. SCHULER: Ground-nets are used in Europe to a great extent, especially in Germany and Switzerland, as the authorities require them for a high-pressure line crossing a highway. It has been found, however, by experiment that in nearly all cases the wire, if broken, will, in consequence of its twist, jump over the side of the net. If a high-pressure line crosses a railroad, the authorities usually require a completely closed tunnel of iron work through which the line passes.

RALPH D. MERSHON: The speaker has put in one or two of these ground-nets himself, but he does not think very much of them. They are generally put up as a matter of sentiment, as a protection in the event of lines coming down, especially from sleet. If it is feared that the lines will come down from sleet, then of course the netting has to be strong enough to carry any sleet that might collect on it. A netting could be put in strong enough to take care of any probable load of ice or snow, but that would mean a rather formidable sort of structure. Probably the best method of protecting lines liable to be crossed by high-pressure wires is, if possible, to put the poles of the crossing line on each side of the line crossed; have these poles close together, and so high that if the upper line breaks it cannot possibly reach the line crossed. Such construction is as near absolute protection to the lower line as you can get against anything short of the main line falling down sideways.

S. B. STORER: The Utica and Mohawk Valley Railroad Company have a short section of their line fitted with the netting underneath. This netting is made of two iron wires on either side of the cross-arm; these wires are twisted and at intervals of about six feet there are three-cornered sticks from one side to the other that are expected to hold the transmission line in case it breaks. The iron wires supporting these sticks are mounted on insulators of exactly the same type as used on the transmission line, so that even if one of the two transmission wires should break there is no tendency for it to ground. The speaker does not like this kind of construction, because he thinks the netting or cradle suspension should be permanently grounded. An iron cross-piece is preferable to a wooden cross-piece for the reason that in using synchronous motors or synchronous converters, one line might break and the two ends drop on this netting, and the machines would go on operating just as they were before. If this did happen, and the wooden cross-pieces were wet, they would carry the current to the iron span-wire thus completing the circuit through the cross-pieces and the iron wire. This would quickly burn the cross-pieces and the wires would drop down just the same as if no support were there. Perhaps it would be much better to have a strong iron netting underneath the transmission line and have the wires of such capacity as to carry a short circuit without burning off.

F. A. C. PERRINE: At the National Electric Code meeting last year this subject was carefully discussed. The Underwriters were at first very strongly in favor of a netting, but the question just asked by Mr. Storer, whether the netting should or should not be grounded in any case, came up at once. It seems important that the netting should have at least as great carrying capacity as the transmission wire itself, otherwise the netting would burn off by reason of the wire grounding.

The second plan proposed by the Underwriters was the one mentioned by Mr. Mershon, that of setting the poles close enough together and elevating them to such a height that a break in the wire could not bring the transmission line in contact with any wire crossing underneath it.

There were, if the speaker remembers correctly, three methods accepted by the Underwriters: first, guard wires placed on the ends of the cross-arm carrying the telephone wires and above them so that the transmission line could not come in contact with the telephone line by breaking. This was the preferred method, and it was left to the discretion of the transmission company whether it would ground or insulate the guard-wires, it being considered that it would make very little difference which was done. The grounding of it would have a tendency to burn off the transmission line, but in either case the transmission line could not come in contact with the telegraph

or telephone wires. The other two methods were admitted as permissive. In the second method the transmission line would have to be raised the height of the street above the telegraph and telephone lines, so that in case of a break it would fall out of contact, which means that in a 60-foot street the transmission line would have to be 60 feet above the telegraph and telephone lines. The third method was the use of a grounded screen. In that case the screen should have more carrying capacity than the transmission line itself, so that in no case would the screen be burned through. All of these systems were recognized as being deficient, but after discussion lasting one day in which the National Electric Light Association, the Pacific Coast Transmission Committee, the INSTITUTE, and the Underwriters were involved, that was the best that could be gotten out of it.

The importance of this is very great, for there has been at least one instance of a transmission line falling across a long-distance telephone line and burning out all the instruments within many miles, and burning down a house. But it is questionable whether these guard-wires are sufficient protection. The speaker thinks there is not yet any very well-established experience.

EUGENE CLARK: Dr. Perrine has not mentioned one serious fault of any form of netting: the transmission span would generally be from 100 to 300 feet long at a crossing, and the netting under the line would necessarily be only a few feet wide. Under such conditions, a broken transmission line would probably curl up and fall off from the netting. Under such conditions, the netting would be useless unless thoroughly grounded.

S. B. STORER: The speaker understands that in Switzerland they make use of a ring projecting from the cross-arm through which each transmission wire passes; these rings are on both sides of the insulator so that if the wire breaks it will strike the ring before the ends touch the ground. These rings are grounded. Has any one here seen that construction, and does it afford protection?

W. B. JACKSON: It is used upon the Valtellina Road in Italy, where the high-pressure wires are equipped in this manner at each road crossing. Although the rings operate very satisfactorily in case of a break in the line, they sometimes give trouble when the lines do not break, and the engineers consequently found it desirable to have them cut out.

PRESIDENT ARNOLD: Why should the ring operate without the wire breaking?

W. B. JACKSON: They found that to give a sure grounding when the line broke they had to make the ring quite small or had to carry it a considerable distance out from the cross-arm, otherwise the wire might drop and not ground; but if they got it too small or too great a distance from the cross-arm there was danger of its becoming slightly displaced and thus causing a ground when such was not desired.

N. J. NEALL: On page 684, rubber insulation is said to deteriorate in a short time. What is the relative depreciation in rubber cable?

JAMES LYMAN: Several cases have come to the speaker's notice of lead-covered, rubber-insulated, single-conductor cable, used for station wiring, where the rubber has deteriorated very rapidly, and broken down after only a few months' service. It is probable that in these cases a high static pressure was induced. The rubber seemed to be cut, and acted upon as if ozone had been present. In one case the cable was used on 13 200 volts pressure, 25 cycles; it was made to stand a working pressure of 30 000 volts, and breakdown pressure of 50 000 volts. After operation of about two months it went to pieces at different times, under normal operating conditions. There was no question regarding the good quality of the rubber insulation. There were six of eight different breakdowns at different times, thus indicating that they were not due to any defect in the cable itself. Another case came to the speaker's knowledge of a single, lead-covered, rubber-insulated cable, used on 13 200-volt, 60-cycle current, good for perhaps 20 000 volts—that broke down in the same way. For these reasons the speaker does not recommend the use of single-conductor, lead-covered cable, either on 25- or 60-cycle work, for station or outside wiring, where the pressure is above 5000 or 6000 volts; below that there is not much danger of the static dischage. The speaker knows of a number of cases where single-conductor, lead-covered cable is used on 6000 volts, and no trouble has been experienced.

DISCUSSION ON "THE PROTECTION OF HIGH-PRESSURE TRANSMISSION LINES FROM STATIC DISCHARGES."

J. S. PECK: Mr. Wirt says: "Many arresters now are supplied adjusted for a breakdown pressure only 50% greater than the generator pressure." While this adjustment is a measure of the breakdown pressure of the arrester at the generator frequency, it does not necessarily measure the pressure at which the arrester will break down under an extremely rapid change of potential; that is, static discharge. All high-pressure arresters now consist of one or more air-gaps in series with a resistance connected between the line-wire and ground.

Tests have recently been made on a number of these arresters to determine the pressure at which they would break down under two conditions: first, with a current of low frequency, such as is developed by the ordinary alternating-current generator; and secondly, by suddenly discharging a condenser through the arrester. It was found that in all cases the pressure required to break down the arrester under the condenser discharge was very much higher than was required at the generator frequency. With the condenser discharge the pressure was measured by means of a spark-gap shunted around the arrester. By placing the spark-gap around different portions of the arrester, it was found that the greater part of the excess pressure required to break down the arrester under the condenser discharge, was taken up by the series resistance.

It is obvious that if a highly inductive resistance were connected in series with the air-gap, the discharge of a condenser through it would be greatly impeded; and it appears that even the straight carbon-rod resistance offers a considerable amount of impedance to the discharge of a condenser. For this reason the speaker thinks that a statement regarding the breakdown pressure of an arrester under generator frequency is of practically no value as a measure of its protective power against lightning discharges.

RALPH D. MERSHON: It is gratifying indeed to know the result of the experiment just cited by Mr. Peck. The writer thinks the result was probably due to the fact that the "non-inductive resistance" was non-inductive in name only.

The question of the accurate adjustment of the striking pressure of arresters is relatively non-important. We do not so much care whether the arresters will discharge at 50 per cent. above the generator pressure, or at 100 per cent. above it, as we do that when they do discharge they will allow to pass sufficient current to keep the pressure of the discharge down to a safe figure and still prevent the generator current from continuing and holding an arc after the discharge has ceased.

Another matter often overlooked in the case of metal cylinder lightning-arresters—a matter which sometimes gives considerable trouble—is the amount of power that they take on

discharge. A 2000-volt arrester with a given number of gaps will take on discharge a given amount of generator current. If on 50 000 volts the number of gaps is increased in proportion to the pressure, the current will be the same on discharge, but the power taken will be about 25 times as great; the result is that if there is a great amount of load on the system there is not enough power left for anything else on the circuit while the lightning-arrester is operating. This condition is especially bad for the operation of synchronous apparatus.

N. J. NEALL: The speaker wishes to take exception to the conclusions drawn by Mr. Wirt—that experience with apparatus damaged by lightning proves that it is as important to provide an easy path for the lightning discharge from line to line as from line to ground.

If we take into account the great distances between the cloud and the line during a lightning disturbance, and the relatively small distances between wires, then, relatively, all wires of any transmission line receive their disturbances as if they were formed of one wire; and it is therefore difficult to see how any difference of potential from this cause could exist between any two wires. It follows that the assumption made—of the necessity for a discharge between wires—does not hold theoretically.

The study and development of protective apparatus during the last eight years emphasize very strongly that certain phenomena occur repeatedly and can be overcome. Generally speaking, if nothing is destroyed in a station equipped with protective apparatus, or if the troubles are comparatively few, the protective apparatus is very highly thought of, although it might turn out that the arresters were really not protecting, and other causes were accountable for relief from lightning disturbances. An excellent plan is to have station operators or line operators record the action of the protective apparatus on their systems, just as they would record the operation of their generators or transformers or any other apparatus which can be metered. A device for this purpose has been suggested, that of using a slip of paper in some of the arrester gaps which would be punctured by discharges. If these papers are removed frequently and systematically doubtless much of the phenomena which we have been studying would have further evidence to substantiate our theories. It is also likely that many troubles would be brought to light that are far more injurious to the normal operation of the line than are lightning disturbances.

Another difficulty is the close setting of spark-gaps to any given pressure. Those who have worked with spark-gaps and spark-gap material know that it is extremely difficult to make measurements and repeat them within five per cent. of the pressure which can be estimated by the ratio of turns. Moreover, it does not seem of such importance in lightning-ar-

resters that we should set our gaps so closely, because if regular apparatus must stand 50% rise certainly any spark-gap can be set to meet such requirement.

F. O. BLACKWELL: Lightning occurs at irregular intervals and in different forms. The kind of arrester which would be best in one lightning storm might be of no value in another. In general, the best we can do is to have a weak point in the system which will allow the lightning to pass through without damaging the machinery. The most primitive form of lightning-arrester, which consists of a grounded pail of water and a wire from the water to the line, furnishing a constant leak to ground, is very effective.

H. C. WIRT: A type of lightning-arrester used in Switzerland and Italy consists of a jet of water turned on the line, so that the line will be discharged through the stream of water. Neither the water-stream arrester nor the horn arrester will take a sufficiently large discharge to relieve the line properly. The principal difference between these arresters and those of American design is in the number of gaps employed. The water-stream arrester with a single gap could be used but the water would have to be of high resistance to prevent an arc holding.

We have not tried either of these lightning-arresters but we intend to do so. The question of the amount of current that an arrester should be designed to take is undetermined. If the resistance used in the arrester is low the current that would follow after a lightning discharge may be large enough to shut down the plant; if the resistance is too high the lines may be only partly relieved and the lightning may then go through some transformer. We should of course consider the lightning-arrester in theory but we should also have extensive tests of arresters under service conditions. The speaker means that no one should decide for or against the use of a ground-wire unless he has been at places where such wires are in use.

R. F. HAYWARD (by letter): The writer believes that it is the apparatus, not the pole-line which needs protection from lightning. If poles get shattered frequently it may, as is pointed out, be necessary to use a grounded wire, but steel construction would be a better remedy.

The transmission lines in Utah, consisting of 300 miles of 40 000-volt pole-line and 125 miles of 28 000-volt line are situated at the base of the Wasatch range where the thunderstorms almost invariably break. These lines are particularly liable to be affected by lightning, and every thunder-storm manifests itself in some way. It is seldom, however, that poles are struck, though there have been several cases of shattered insulators and splintered poles. With duplicate lines the striking of a pole should cause but a short interruption, and the damage is easily repaired. But if the transformers are damaged a whole station may be temporarily disabled,

and the damage is costly. When a pole-line is struck a wave is set up which finds its vent in a lightning-arrester, breaks itself against a transformer coil or breaks down the coil. If the insulation of the coil stands the shock and there is no lightning-arrester discharge, an arc may form from terminal to case. Experience seems to show that a lightning discharge has the greatest effect on the station nearest to it, but that the horizontal discharge, occurring between clouds and more or less parallel to the lines, produce some of the most severe shocks at lightning-arresters or transformers. In the neighborhood of Salt Lake City it seems that there is a greater tendency to horizontal discharges between clouds than to lightning discharges direct to ground. This is doubtless due to the abrupt rise of the mountains from the level of the valley. There is no doubt that lightning can and does induce very high pressure waves between wires, many instances having occurred in Utah. Protection should therefore be provided against this.

The writer is in doubt about the use of reactive coils, as there are instances which show their value and others which do not. It seems that a reactive coil to be effective must be pretty large. It has occurred in the writer's experience that a pole has been struck with lightning and at the same instant a discharge has occurred from transformer terminal to case, while there was no discharge over lightning-arresters, although a reactive coil was in circuit.

Instances showing that a transformer coil or the windings of an armature act as a " breakwater " to the passage of high-frequency waves are too numerous to mention. One instance is interesting. One of the 2000-volt circuits supplying Ogden City is lead from the power-house through booster transformers. A severe storm occurred when the boosters were not in circuit and a discharge took place across the collector rings of one of the armatures in the power-house. A few days later a similar storm occurred when the boosters were in circuit and one of them was burnt out.

The writer believes that reactive coils of comparatively cheap construction should be put in to satisfy the conscience of the engineer, but for real protection the money should be spent on the transformer. An 80 000-volt transformer working on a 40 000-volt circuit and protected by a 40 000-volt lightning-arrester ought not to break down. The writer's opinion has changed somewhat during the past year in this matter and he now believes that any reactance coil of large capacity introduces some extra apparatus and additional wiring, whereas the same money spent in the transformers themselves ought to provide sufficient insulation to stand these shocks.

The writer believes that lightning-arresters should be adjusted so that they are near the limit of their own safety; plenty of spare parts should be provided and an occasional burn-out

of the lightning-arrester resistance should be accepted as proof that the lightning-arrester is giving some protection. Anyone can put so many gaps and so much resistance in an arrester that it will never burn out, but it does not follow that this arrangement affords any protection.

P. H. THOMAS (by letter): Static discharges in high-pressure transmission lines arise from two causes: first, abrupt changes of potential caused by switching or accidents in the transmission system itself; secondly, lightning.

The best protection against the first class, which are certain to be quite numerous, is in providing ample insulation in the design of the plant, not so much in the heavy thicknesses of the solid insulating material, which is exceptionally strong to resist static strain, as in the air distances, oil distances, and surface distances between exposed points. In the opinion of the writer, it is extremely important that these distances be ample. For instance, they should be laid out to stand with certainty double the normal pressure of the system, since probably in very few cases would static pressures exceed this limit, except of course in case of lightning. It is true that pressures of startling magnitude are occasionally reported from transmission plants, but in few cases have the existence of such been clearly proved, and in many cases the reports have proved to be unfounded.

In laying out surface distances and air spaces, it must be remembered that the jumping power of high pressures increases much more rapidly than the pressure itself. Distances should not be doubled for double pressure but a curve of actual tests should be used. It must be remembered as well that surface distances have their insulation strength much deteriorated by a deposit of moisture or of conducting dust, and that some kinds of material, notably hard rubber, may have a gradual deterioration. It must also be noted that the jumping distance over a surface is much affected by the presence near that surface of another conductor at a different pressure. For example, a wire within a bushing, and the presence of such a conductor, in extreme cases may increase by several times the jumping distance of a given pressure. *This fact is very well established and has been given entirely insufficient recognition in laying out surface distances for insulation.* Still another factor weakens the insulation strength of surfaces when subject to static discharges; namely, the fact that for an abrupt change of pressure a considerable quantity of electricity must flow at the time of the application of strain to charge up the surface of the insulation near the charged conductor, and this flow of current momentarily weakens the total insulation strength of the surface.

It appears to the writer that since a great mass of data with regard to the effect of ground-wires or other devices on the elimination of troubles due to lightning is required to eliminate

the effect of conditions other than those being studied, that little can be gained from the consideration of one or two cases of ground-wires, and that all our accurate data furnish an insufficient basis for conclusions at the present time. It seems unlikely that even though the grounded wires may be proved to have protective effect, as they undoubtedly do, they will ever be of general use, in view of the mechanical and electrical difficulties and expense involved. As Doctor Perrine has stated, there is a tendency where ground-wires are brought near to high-pressure conductors, for current to be set up in the ground-wires, causing more or less energy loss and possibly other difficulties. Furthermore, there is an increase of electrostatic capacity, due to the presence of ground-wires in the neighborhood of the high-pressure conductors. These objections may be much less critical on low pressure, short-distance plants. In some such plants ground-wires may turn out to be the best ultimate protection.

Experience shows that direct strokes of lightning must be expected on transmission lines in most localities. Unless grounded guard-wires are used, these strokes must inevitably injure poles. Such injuries, however, often do not cause a shutdown of the plant. It is highly desirable for these severe discharges to get to earth as quickly as possible.

Arresters in the station constitute the most approved practice and will be relied upon in most cases. In very important high-pressure plants, however, it would seem that where regular attendance is feasible a set of arresters at a point from one-half a mile to two or three miles from the station would be a very desirable precaution. In such cases where constant attendance is not feasible, but where there is a suitable location for arresters, the use of fuses, possibly arranged so that when one blows another comes into service, would be satisfactory. In such cases, should trouble occur at the arresters, the line would clear itself immediately.

Reactive coils may serve two functions: the prevention of short-circuit strains between the turns of windings, for which purpose they are especially suited, and to assist the discharge of lightning-arresters to ground by delaying the rise of pressure of a transformer terminal at a time of static disturbance. In either case the protection derived from the reactive coil is a matter of degree, depending upon the relative electrical characteristics of the transmission line, the windings of apparatus, the arresters, and the pressure of line. A given coil may be very effective on one circuit at one pressure, and entirely inadequate for another circuit on another pressure. A freely-discharging arrester on a line of small electrical capacity, protecting apparatus itself having a large electrostatic capacity near its terminal, would require comparatively the smallest choke-coil for restraining the ultimate rise of potential above ground. An arrester with a ground-

connection on a line of large electrostatic capacity and high-pressure, where the apparatus to be protected has a comparatively small electrostatic capacity near the terminal, would require a coil very many times more powerful to obtain the same protection to ground than the coil of the first case.

For the protection against short circuits in windings, the choke-coil must be proportioned in its choking power to the number of turns, etc. and the winding itself, at least approximately; and to be effective without being unduly large can oftentimes be advantageously assisted by the use of a condenser connected between the terminal of transformer and ground. It would seem evident from the above that reactive coils should be of a power adapted to the circuits upon which they are to be used.

N. M. SNYDER (by letter): On the assumption that the line-wires of a transmission line have capacity, it might be said that when we use an overhead ground-wire as suggested, the nature of the protection afforded seems to be due to the static charges surging from the line-wires to the ground-wire, as evidenced by the jumping of the arc across the transformer leads above the oil. This shows capacity in the circuit. The writer concurs with Mr. Wirt in saying that we should be able to protect stations and apparatus without resorting to the use of the ground-wire. If we make the same conditions at the station as existed when the grounded line was used, it should be of material benefit. If we connect a plate or series of plates, equal in capacity to the wire to be protected, at the power-house and sub-station and do this with all wires, arranging them symmetrically and equidistant from a central or ground-plate of equal area, should we not have an ideal static arrester? As long as the wire or wires are balanced and current is flowing equally in all, no interference should be experienced in retardation by the ground-plates, nor any serious faults from resonance. A static disturbance occurs; it surges from wire to wire as through a condenser; the ground-plate is neutral to the plates of the wires; so any charge of static on either wire will promptly be communicated to the ground-plate and relieve the strain. Of course in adjusting the plates care should be taken to have them sufficiently separated to exceed 25 per cent. higher pressure than that of the generator. This will prevent the breaking down of the air-gap, the principle being to make a static line balance normally; and when any excess of static occurs it is quietly induced to earth in an efficient manner by making use of the condenser principle.

JOHN PEARSON (by letter): There is one point in regard to the grounded wire with which the writer thoroughly agrees. The writer considers that the grounded wire cannot well be used: first, on account of cost; secondly, because with this wire a short circuit may easily be established; thirdly, because it does not afford complete protection to apparatus at gen-

erating or distributing stations. For more than three years the writer has been with a company operating a 4000-h.p. power-plant (not using the grounded wire) located near Somerset, Wis. This plant transmits current to St. Paul, 28 miles distant, at 25 000 volts pressure. During this time only three poles were split so that they had to be removed, but not so badly as to interfere with the operation of the plant. Another plant, only four miles distant, with a pole-line running through a hilly country, and not using the grounded wire, has not suffered at all from poles being shattered by lightning; but it has suffered a great deal from lightning, due to inefficient lightning-arresters.

From this and other data, it seems that lightning- and static-arresters can be arranged so as to be of more protection than the grounded wire. Experience proves it necessary to provide: first, an easy path from line to ground, through which the line wires may be relieved of high pressure in respect to the ground; secondly, to provide choke-coils between arresters and apparatus to be protected, so as to give the arresters more time to discharge; thirdly, to provide the multiplex connection which Mr. Wirt suggests on the arrester side of choke-coils so as to provide an easy path from line to line; fourthly, to provide the high-pressure winding of transformers (or generators) with a static by-pass between sections of such windings. This is done by bringing out a number of leads, at equidistant points, from the high-pressure winding of a transformer or generator to be protected, to provide metal knobs and series resistance between these leads, so that normally this combination is a non-conductor, but at say 50% increase in pressure across a section this combination becomes a conductor, and relieves the particular section which it is designed to protect.

The writer knows that when the lightning-arresters which are connected to the *line side* of choke-coils discharge, great differences of pressure are set up between wires on transformer or generator side of choke-coils. This difference of pressure frequently causes a flash from lead to lead in transformer top, and sometimes will break down the insulation between layers in transformer coils, especially the layers next to line wires. An efficient remedy for this is to provide an easy path for the discharge outside of the transformer top, by bringing out leads and joining as suggested above. One feature about connecting a static by-pass over successive sections of the winding is that it will take no more pressure to break down all the air-gaps across the whole transformer winding than it will take to break down the air-gap across a single section, owing to the fact that all the gaps are not broken down at the same instant. This idea in transformer protection has been used for over two years at St. Croix Power Co.'s plant, Somerset, Wis., and has also been installed at a new plant in New York State.

Prior to using this form of protection for transformers, the St. Croix Power Co. lost four transformers in one season, caused by static jumping from lead to lead in transformer top; since then there has been no loss from similar causes. In Fig. 1, A represents the core of a high-pressure transformer; C the low-pressure winding; C'—C' terminals of this winding. B represents the high-pressure winding; B'—B' represent the terminals of this winding. Leads L-L are brought out between

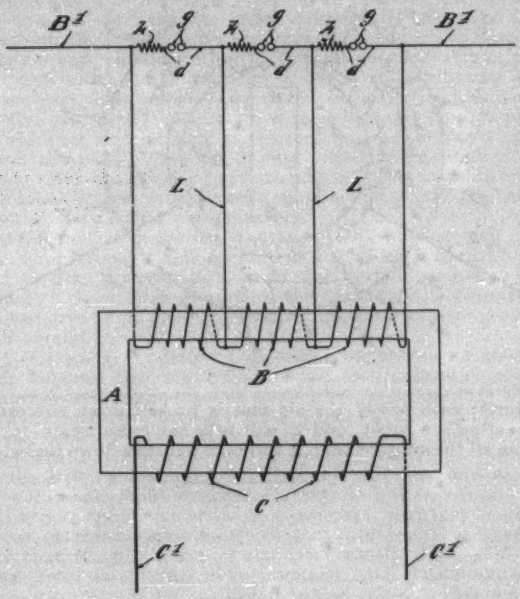


FIG. 1.

terminals of this winding, dividing it into three sections in regard to static-arrester, and between these leads are provided non-inductive resistance, k, metal knobs, g, with their air-gap, also wire (or conductor) d.

Fig. 2 shows this scheme connected to a high pressure generator with revolving field. The connection is the same as in

Fig. 1. Referring to Fig. 1, it can easily be seen that there exists great strains between B'-B', due to lightning arresters discharging or other causes (this charge being of an oscillatory

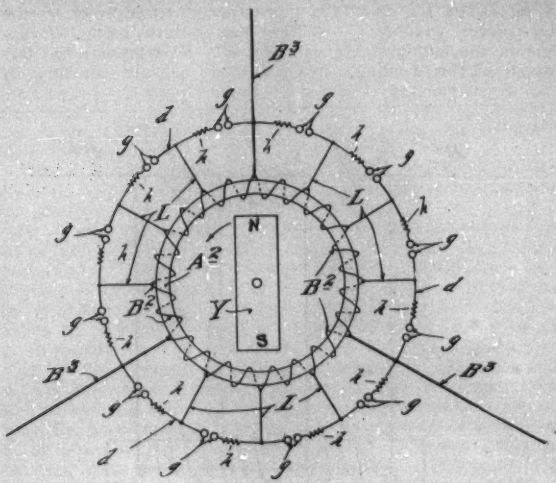


FIG. 2.

nature); each one of the air-gaps is broken down successively, one after the other, and it will take no more strain to break down all the air-gaps than it will take to break down a single gap.

Discussion on "The Use of Ground-Shields in Transformers."

Ralph D. Mershon: Undoubtedly, if grounding the neutral of a low-pressure winding does not protect, protection will not be obtained by the use of ground-shields. It seems to the speaker that it is not safe to install a high-pressure transmission system, feeding a city distributing system, without either making use of ground-shields or grounding the neutral of low-pressure windings. Aside from the question of a cross between the high- and low-pressure circuits, it is possible, with everything in good condition, to have electrostatic effects of high pressure on the low-pressure windings, high enough to damage insulators and endanger life. It seems therefore that it is rather unwise to install transformers feeding distributing systems without using one of these means of protection. In some cases the expedient of using spark-gaps between the low-pressure windings and ground is resorted to, and in some cases between the neutral and the ground instead of grounding the neutral. But these spark-gaps are generally the cause of more or less trouble; it is the speaker's opinion that it is much better to ground the neutral permanently.

H. C. Wirt: Transformers having ground-shields were used to a limited extent in this country at a time when the National Board of Fire Underwriters would not permit grounding the secondary. Now that grounding the secondary is permitted, there seems to be no good reason why transformers with ground-shields should be used.

C. E. Skinner (by letter): In specifying the use of ground-shields between the high-pressure and low-pressure windings in transformers, engineers seek to prevent any possibility of an electrical connection between these windings. The question to be considered is, therefore, whether or not this result can be accomplished.

In the writer's opinion, ground-shields are very undesirable from a constructional standpoint; they do not necessarily accomplish the result for which they are used, and they increase the cost of transformers in which they are used. The writer agrees that the grounding of the low-pressure winding at the neutral point is a safer, more practical, and cheaper method of protection than is the use of the ground-shield. This method gives almost absolute safety, while the use of the ground-shield is at best a doubtful expedient.

P. H. Thomas (by letter): Mr. Peck has hardly emphasized sufficiently the objections to the use of ground-shields in large high-pressure transformers. That a very efficient protection against the raising of the pressure of the low-pressure winding of transformers, due to a certain class of breakdown, is secured, cannot be denied, but the incidental difficulties and opportunities for trouble introduced through the use of ground-shields far

outweigh its advantages, when protection can be so simply obtained otherwise.

The writer fully agrees with Mr. Peck's conclusions, but wishes to bring out one point: when the grounding of the neutral point of the system is relied upon for protection, there is one weak point. From the nature of the case, the connection between high pressure and low pressure, when occurring on wiring or at the leads of transformers, will be of the nature of a static discharge, also the low-pressure winding of the transformer constitutes a choke-coil between the source of the disturbance and the grounded point; as a result there will be a short-circuit strain impressed upon it of a very severe nature, which may easily cause a breakdown of insulation. This may be avoided by using lightning-arresters as discharge gaps on the leads of the low-pressure winding. This method will not be effective where the connection between high-pressure and low-pressure systems occurs at an intermediate point in the winding of the transformer. Since in this case the transformer is already injured, this fact will not be of such serious consequence.

W. L. Waters (by letter): A ground-shield undoubtedly affords some protection, but such protection can be obtained in a much simpler and more reliable way by grounding the low-pressure side of the transformer, or by means of some automatic grounding device, such as the Cardew. Considering the question from all points, the writer agrees with Mr. Peck, that the doubtful protection afforded by the ground-shield is obtained at far too high a cost, and that at the present time a ground-shield would be more suitably placed in a historical museum than in a power transformer.

Discussion on "Conditions for Continuous Service over Lines Operated in Parallel."

Ralph D. Mershon: There is one point which the speaker would like to have taken up because of its bearing upon a grevious discussion at Niagara Falls. The speaker refers to reverse-relay devices; they are interesting things to talk about, but does anyone know of a reverse-relay device that will work under all conditions?

P. H. Thomas (by letter): Absolutely continuous service may be realized in theory and ultimately will undoubtedly be closely approached in practice. At the present time, however, no such perfect devices are available.

The usual arrangement of overload circuit-breakers at the generator end of two transmission lines in parallel and reverse-current relay circuit-breakers at the other ends does not operate properly in all cases when there are generators at both ends of the line. A theoretically satisfactory arrangement can be constructed, however, which will open the right line at both ends in all cases of short circuits by operating at all points at which the lines are paralleled, the relays controlling the circuit-breakers jointly from current transformers connected in the two lines. These currents must be so directed that during an equal division of load between the lines (or division in any desired proportion if so desired) the influence of one line shall just neutralize the influence of the other line. When with this arrangement current is reversed in one of the transmission lines, the influence of two lines is in the same direction in the relay and can be made to open the defective line.

Another method appears to the writer to have a number of advantages. In endeavoring to maintain continuous service with apparatus now available, the system having duplicate parts all through may be operated as two systems entirely independent electrically, each so arranged as to carry approximately one-half load. Each of these systems should of course extend into all important sub-stations. In case of trouble to one line causing a drop of pressure, half of the load of the system will be dropped. Immediately this should be thrown to the other system, which must of course be able to carry the double load for a short time. If the attendants are properly instructed this may be done without special orders from headquarters, thus avoiding a very important loss of time. All parts of the dead system which are uninjured may then be immediately paralleled with the live system, enabling it to carry the full load easily.

Discussion on "Protection of Cables from Arcs Due to Failure of Adjacent Cables."

Ralph D. Mershon: In addition to the protection of cables in manholes, there is also the question of the protection of cables in power-stations. It is not always easy to install cables in such a way that they will be protected from each other, especially if the power-house has not been laid out with reference to them. The question of protecting cables by means of asbestos and similar wrappings has for its chief objection that there is no chance to get rid of the heat in the cable. For that reason, and for the greater one of reliability, the speaker very much prefers either tile or brick protection to asbestos.

Mr. Carlton speaks of using a voltmeter for determining the current being carried by the cable sheath. Will Mr. Carlton please explain a little more fully the method of using the voltmeter, and also the method he prefers for permanent grounding of metal sheaths?

W. F. Wells: Mr. Carlton refers to two independent lines of subway as being an insurance against trouble on a high-pressure cable system. In New York this practice has been carried a little further, and four separate and independent trunk subways have been installed, leading from the generating station along four different routes. From these trunk subways run branches arranged so as to give each substation two or more feeders, following entirely different subway routes. In case of a manhole caving in, or general trouble on any subway line, not more than one quarter of the high-pressure cable system can be affected.

Regarding the injury to high-pressure cables by the burning out of low-pressure cables, this has occurred, but burn-outs have also originated in the high-pressure cables. Some of these troubles were due to defective joints and some to short bends in the cable where it leaves the duct. In order to obviate this latter cause, the cable is now run straight out of the duct 12 in. before bending it over to the side of the manhole, thus preventing the edge of the duct from cutting into the sheath of the cable.

For the past two or three years the high-pressure cables in manholes have been wrapped with asbestos bound on by galvanized-steel tape, as described by Mr. Carlton, and the results have been very satisfactory. No trouble has been experienced from the heating of the cables where covered with this asbestos wrapping. In the stations, clay ducts or iron pipes are used wherever possible to protect the lead-covered cables, and, when there is sufficient space, braided cables are carried on insulators through runways of brick 12 in. square.

H. C. Wirt: Will Mr. Carlton state whether he considers an underground line more reliable than overhead line as regards interruption of service?

Ralph D. Mershon: Mr. Carlton speaks of the extra ex-

pense of separating ducts. It seems that in some cases separation may not in the end be an extra expense. The capacity of the subway is not necessarily proportionate to the number of ducts in it. Allow a certain limiting value to the temperature of the cable, then the ducts near the center of the conduit will not be as effective as those outside, no matter how they are arranged; if they are separated, it might be cheaper in the end because of the greater capacity the two subways would have over the single. So far as the speaker knows there are no accurate data in regard to this matter. The speaker has done a little work himself in special cases, and some work was done at Niagara some time ago. Perhaps Mr. Carlton and Mr. Wells have some information on this subject.

W. G. CARLTON: In regard to the capacity of the cable being lessened in a larger conduit line; the speaker has no accurate information on that subject. Where cables are run at extremely heavy loads the gas generated inside of the cable will puncture the lead sheath, and this is one of the limiting features. The permissible watt consumption per linear foot of cable depends on the number of cables in one conduit line. With a single cable 20 watts per foot would probably be safe; with a larger number of cables, three or four might be the limit.

It is a good plan to treat the cables in the power-house—if they are lead-covered ones—practically the same as you would for underground construction. A conduit line can either be built, or when the cables are in place they can be covered with split clay tile. The ends of the cables need special care. Three-conductor cables must have some sort of terminal bell which allows spreading out the conductors for connection to the single-conductor cable, this bell to be filled with an insulating compound.

In regard to detecting possible stray currents on the lead sheaths of cables; a Bristol recording meter with a five-volt scale has been used; this is fairly satisfactory. A meter with the zero line in the middle of the chart and giving readings each side of this line would be much better. The voltmeter is connected between the lead sheath of the cable and a good ground. In our stations we connect with the ground plate; we have a ground bus-bar in our stations connected to several ground plates. In a manhole it would be connected to a water-pipe or sometimes to the cast-iron frame of the manhole or to a rod driven in the ground. The grounding of the cable sheaths is done ordinarily in the power-house, on the brass bell on the end of the cable.

Answering Mr. Wirt's question in regard to overhead and underground lines; in the case of one company operating possibly 75 miles of 9000-volt lines, 65 of which is underground, possibly 90% of the trouble on the lines is on the 10 miles of overhead line. This has been caused generally by boys throwing wires over the line, or by kite-strings.

H. B. ALVERSON: When the asbestos covering a cable is saturated with silicate of soda, the wrapping will harden and become nearly as good a conductor of heat as the lead jacket; this overcomes the objection that asbestos covering confines the heat within the cable.

W. G. CARLTON: How does that stand in a wet manhole?

H. B. ALVERSON: We have had no experience of that sort.

E. M. LAKE (by letter): In visiting some of the larger Eastern stations, about three years ago, it was observed that very little attention had been given at that time to the protection of outgoing cables. The bus-bars and immediate connections were protected by a most elaborate scheme of barriers built up of brick and concrete and of soapstone. The outgoing feeder lines, however, and in one or two places the main leads from the generators, were laid side by side upon cast-iron racks or upon thin sheet-steel shelves.

When this question came up in connection with the design

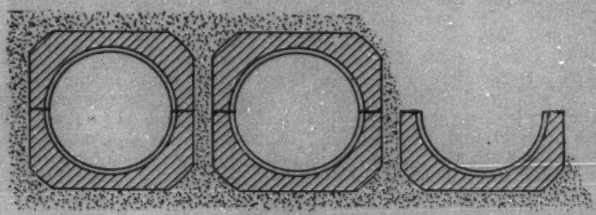


FIG. 1.

of certain Chicago sub-stations several methods were considered for protecting and isolating the whole cable equipment so as to reduce to a minimum the liability that a burn-out would spread to adjacent cables. The plan of using thin slabs of slate or vitrified clay was not found feasible because of the difficulty of applying in places where the structural work and cables were already in place. Then, too, this plan did not afford a simple and ready method of completely enclosing the cables where there were several in one run. Steel shelving and partitions when used alone were open to the same objections, besides being still further objectionable on account of the very small resisting power when subjected to the intense heat of an electrical burn-out. The proposition then narrowed down to some form of vitrified clay conduit because of the convenience of form, good mechanical strength, and high arc-resisting powers. Since the application must very often be made to cables in place, a split or divided form was necessary. There were found two forms of split conduit. One was divided in a straight line upon the diameter of the bore (Fig. 1). The other

was divided at an angle to the diameter, the two parts not being symmetrical (Fig. 2). These conduits were each applicable to certain conditions and locations, but a form was desired that would adapt itself readily to any and all places where protection of this kind was required. The style designed for this purpose was divided on lines parallel to the diameter of the bore but offset about an inch with reference to the diam-

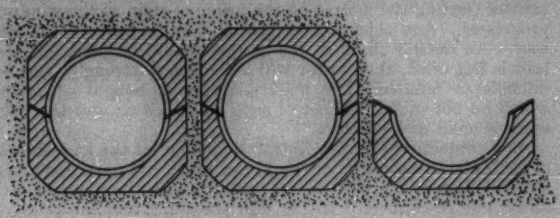


FIG. 2.

eter (Fig. 3). This gave two symmetrical sections which were interchangeable and possessed several distinct advantages over the existing forms.

It will be observed that in this form of conduit the joints in two adjacent ducts are not directly opposite. This of course insures a much more effective barrier between the cables enclosed by the conduit. For horizontal runs in walls the form

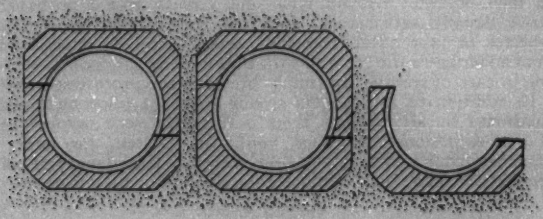


FIG. 3.

of the half-section is such that when laid it forms a convenient bed for the cable. Then when the cable is in place it does not form an obstruction to the laying of the remaining half of the conduit. Elbows on a safe radius for large cables and in an arc of 45 degrees were provided. Short straight lengths of 4½ in. and 9 in. were also ordered. With these forms and the standard 18-in. lengths it was comparatively easy to follow

the curves of any run of cables in a station or manhole, provided the cables had not been laid on less than a 12-in. radius.

A. M. HUNT (by letter): A covering for leaded cables where exposed in manholes can be made as follows: mix a stiff mortar using calcined magnesite (finely ground) and a saturated solution of magnesium chlorid; this combination hardens to stone in a few hours, and is heat-resistant and water-proof. Coat the lead of cable with oil, and wind it spirally with strips of canvas, putting the mortar on the inside of strip as the winding progresses. Any thickness of coating may be built up in this way. An outside finish of the mortar should be used. If the lead is not oiled, the mortar will adhere to it strongly, and be difficult to remove. The materials can be bought at prices which do not make the cost of such work heavy, and the covering is solid and effective.

As a protection against electrolytic action on the lead sheath of cables in an extensive network, the writer has tried operating a direct-current machine of low pressure with the negative terminal solidly connected to the lead sheathing and the positive strongly bonded to rails. The sphere of influence of this machine was much more extensive than might be imagined, and the application is worthy of consideration in cases where electrolytic action is severe. In the case noted the energy consumed was quite small.

J. W. F. BLIZARD (by letter): The writer suggests wrapping the cable in manholes with tape or thin asbestos, and then spreading a layer of about one-eighth inch of litharge on the cable. This will harden quickly and form a perfect protection from arcs, and may with ease be extended into the ducts for an inch or two. Ground mica and varnish would probably prove equally satisfactory, and cost considerably less. The asbestos or tape covering would prevent the compound used from adhering to the cable sheath, thus making the cable accessible in case of trouble, by simply breaking the protecting shell.

In addition to the dangers arising from the unconfined arc mentioned by Mr. Carlton, there is the often very serious one of gas explosions. No good ventilating system for underground conduits having yet been devised, this danger is an ever present one, and its importance should not be underrated.

GENERAL DISCUSSION ON HIGH-TENSION TRANSMISSION MATTERS.

W. G. CARLTON: Regarding the comparative reliability of overhead and underground lines, President Arnold and Mr. Wirt have both pronounced in favor of the overhead line. The speaker would like to hear something of the conditions under which President Arnold was considering this question; it seems that there are not very many cases where overhead lines can be the more reliable.

PRESIDENT ARNOLD: Of course it is not advisable to make a general statement that the overhead line is the more reliable and is always the line to install, because it is well known that in city work the use of underground or conduit is practically compulsory, in these circumstances it is unquestionably the more reliable because it is not subject to malicious interference, at least not to any such extent as an overhead line might be. When considering transmission lines, extending across country or through a region more or less settled—especially on private right of way—the speaker's conclusions are the same as those of his associates, that the overhead construction is preferable. It is preferable for two reasons: first, much less in first cost, and presumably in maintenance; secondly, it is much more accessible to repair in case of accident, because the trouble may be easily located and quickly repaired. These advantages do not obtain in the case of underground or conduit work. Any one that is installing electrical plants will admit that it is cheaper to construct overhead lines, and where these lines are permitted they are usually installed.

CHARLES F. SCOTT: President Arnold has said that underground wires are considerably more expensive to install than overhead wires. About what per cent. of the plant investment is represented by the transmission construction?

PRESIDENT ARNOLD:—Our case is one which would make the underground construction cost more in proportion to the overhead than in ordinary cases, for the reason that there are so few wires to carry, the maximum number being six and part of the way only three wires. In building this line we are running through rock almost all the way and will have to blast a large part of it. It is a case of digging and blasting a trench 57 miles long, so our preference for an overhead system is obvious.

PETER JUNKERSFELD: In replying to Mr. Scott's question, a comparison might be made with the high-pressure 25-cycle transmission systems in large cities, many of which represent from four to seven per cent. of the investment in the entire central station system. In the case in question the percentage would not be much higher, and probably is lower because of the heavy investment in car equipment, track construction, power-houses, and so on.

PRESIDENT ARNOLD: Perhaps it will be lower than that. The speaker cannot give an exact figure.

RALPH D. MERSHON: A plant with which the speaker has been associated has a transmission line of about 17 miles in length. The pressure at the terminal station is 22 500 volts. The last 3600 feet of this line consists of four three-phase cables each 3600 feet long. This line has been in operation for about three years. During that time, so far as the speaker knows, there has not been any trouble with the cable, except once when a defective joint was at fault, due to bad workmanship when the cable was installed. This cable is protected by choke-coils and lightning-arresters at the terminal house where the overhead line enters it; and although there are on this transmission system two grounded wires for protection against lightning, yet lightning occasionally comes across the arresters. Some short pieces of the cable are used for wiring at the generating station, and have at times a pressure of 25 000 volts. The neutral point is grounded at the generating station only. In this installation the cable-bells are made of hard rubber, with leads brought up through hard-rubber tubes, the bells being filled with paraffin.

N. J. NEALL: The allowance for depreciation of poles is, to-day, an important item in the fixed charges for a transmission line. It would therefore be interesting to know whether this statement as to life of various kinds of poles represents the depreciation as estimated by the various companies answering these questions, or the years they have used the different kinds of woods, or their opinion as to the relative values of different woods expressed in depreciation.

PRESIDENT ARNOLD: We can say offhand that very few maintain that a wooden pole will last for 15 years or even for 10 years. It is likely that the figures given in the report represent the life of a pole from a theoretical viewpoint. A pole may last for 10 or even for 15 years—subjected as it is to continuous attacks from the elements—but 15 years is assuredly the maximum limit.

RALPH D. MERSHON: In his Introduction Mr. Carlton barely touched upon the question of the possibility of high-frequency pressure effects due to an unconfined arc from a defective cable. Will Mr. Carlton please refer to this matter now?

W. G. CARLTON: Only one case of that kind has come to the speaker's attention. It happened in New York, and did considerable damage. In our experience in Chicago nothing of that kind has happened, but there is always a possibility of it happening.

CHARLES F. SCOTT: There is a station in New York, the Kingsbridge station, which has been operating for a year or two with open-air switches. It operates at 6600 volts, sometimes in parallel with the other power-houses.

W. G. CARLTON: This possibility of a rise in pressure in opening a high-pressure circuit in the air is generally conceded. A number of tests made here by Mr. Eastman have demonstrated it, and the results are decisive.

G. N. EASTMAN: The tests were made on a three-mile length of 2/0 three-conductor, paper-insulated, lead-covered cable with only the charging current of the cable. A static voltmeter was connected between one conductor of the cable and ground and an oil-switch and air-switch connected in series with the cable, so that they could be opened alternately. The oil-switch was so arranged that one break or a number of breaks in series could be made. The air-switch had but one break. By opening the air-switch very gradually, drawing out the arc, the rise in pressure was 40 to 50% above the normal. With the oil-switch no rise in pressure could be detected when the switch was opened having several breaks in series; with one break only a slight rise was detected when the switch was opened very slowly. These tests were duplicated, using the spark-gap instead of the static voltmeter, and the same indications were obtained. When the air-switch was opened, the charging current increased as the length of arc increased. By carefully drawing out the arc, a charging current seven times its original value could be obtained.

RALPH D. MERSHON: In his introduction Mr. Carlton seems to intimate that if a fire-proof cover were installed around a cable, thus confining the arc, there would be no oscillation; if the arc were not confined there probably would be oscillation. Has Mr. Carlton made any experiments that would justify this intimation?

G. N. EASTMAN: No; but the same conditions would prevail in the case of a short circuit as would obtain in the switch when opening under certain load conditions. From the results of experiments made by Dr. Steinmetz the speaker believes that he recommends the wrapping of cables in order to confine the arc.

RALPH D. MERSHON: Granting that a rupture of short circuit by oil might give very different results from an arc in air, it doesn't necessarily follow that you get in a confined arc the same results you would in oil. Has there been, so far as you know, any definite experiment tending to show pretty conclusively that cables protected in this way if they burn out are less likely to produce dangerous oscillatory effect than if they burn out in the air without this cover?

G. N. EASTMAN: So far as personal knowledge goes, no experiments have been made along this line, but the harmonic which is evidently obtained appears to depend upon the length of the arc. For instance, in all of the tests which were made in interrupting the charging current of the line, a certain length of arc would give a definite charging current, and an increase in the length of arc would give an increase in current.

H. B. ALVERSON: The speaker has witnessed tests of oil-switches with an ordinary steam-gauge put on the breaking chamber, the amounts of oil being varied from nothing up. In opening under oil the pressure varied from 50 lb. to 300 lb. depending on the point on the curve where it was broken, and an oscillograph in the circuit showed no pressure rise. With air only in the chamber, the air pressure would be from 10 lb. to 15 lb., while the oscillograph would give variations in which the pressure rise would go as high as twice normal pressure, the results being similar to opening arcs in air.

RALPH D. MERSHON: One would think that in a three-phase cable a short circuit would result in a definite length of arc determined by the distance between the conductors, and that there would not be much variation in the length of this arc. It seems to the speaker that unless definitive experiments are made with actual reference to the short-circuiting of cables—closed or open arcs—one could not draw satisfactory conclusions.

G. N. EASTMAN: We have had some short circuits happen between the conductor and ground, and the circuit-breaker at the station opened before the short-circuit had sufficient time to destroy the insulation between conductors. In one case where this occurred, the conductor on which the short-circuit was established was burned in two, but the insulation remained sufficiently high on the other two conductors of the cable to allow their being operated at the normal system pressure. This occurred on the 9000-volt system of the Chicago Edison Company in which the neutral was grounded, and the ground which occurred was a direct short circuit on one phase of the generators.

F. WOODMANSEE: The speaker was interested in making a test at Kalamazoo, a few years ago, to determine the effect on line due to the rupturing of the circuit by means of oil- and air-break switches. In that test it was found, in breaking a loaded circuit with an air-break switch, that surging occurred at instant of breaking the arc, but when rupturing the circuit by means of oil-switches there was practically no surging at all. These results were verified by spark-gaps connected across the line, as well as by means of an oscillograph.

The breaking of the circuit by means of allowing the arc to rise and break from what is known as a "goat-horn" was tried. On two occasions the light breeze extended the arc until it was about 33 feet long. At that instant it short circuited the load and reactance-coil, making a dead short-circuit on the system. On opening the switch there was a pressure rise on line of at least three or four times that of the operating pressure. This was verified by the spark-gaps. These tests demonstrated that the rupturing of high-pressure heavily-loaded or short circuits by means of air-break switches was dangerous, while they could be opened with safety by means of oil-switches without any very great rise in pressure.

RALPH D. MERSHON: Have any experiments been made with definite arc length? In opening an air-brake switch the practice is to start from zero arc and increase gradually until the maximum arc of this switch is reached; in doing this the length of arc may be struck that will give surprising results, results that might not be obtained with short arcs.

It seems to the speaker that Mr. Carlton's Introduction contains a timely reference to the very important subject of protecting cables from one another when one of them happens to fail. Now if the idea is simply to protect these cables from the heat of adjacent arcs it might be done by the scheme outlined by Mr. Carlton—the use of tile or brick—but if in addition we can, by asbestos wrapping, protect to a more or less extent against abnormally high pressure due to oscillatory effects, then it would seem that the protection by such wrapping were much to be preferred. Up to the present time, this discussion has failed to elicit any definite data as to the effects resulting from the burn-out of a cable,—the question naturally arises, will there necessarily be a higher pressure with the open air than with the enclosed arc?

F. WOODMANSEE: Regarding the first point raised by Mr. Mershon, an instrument was used to determine the length the arc was drawn out. This instrument was used with both the air-break and oil-switches. The shorter the length of arc the less pronounced the surging effect.

W. G. CARLTON: Referring to Mr. Wirt's remarks, the asbestos wrapping would protect the cable from arcs due to adjoining cables; but in the case mentioned, the sheet-steel covering was used to confine the arc. If a high-pressure, three-conductor cable burns out and the circuit-breaker does not open the line, there will not be any cable or asbestos left where the arc is; in some cases three or four feet, or even more, of the cable has been entirely destroyed.

RALPH D. MERSHON: Of course if cables are laid on tile shelves and not wrapped or covered with the iron sheathes mentioned by Mr. Carlton, there would not be any confining of the arc. Now in order to avoid any dangerous effects from the arc—if the effects can be avoided by confining the arc—the arc would have to be confined in such a way as to develop a fair amount of pressure. If this were done, some precautions would have to be taken as to the strength of the encircling protection. In the case of asbestos-wrapped cable and a burn-out the speaker would like to know if any of the wrapping has been blown to pieces. Under some conditions there might be a considerable amount of pressure developed in asbestos-wrapped cable, enough, perhaps, to destroy the wrapping.

F. WOODMANSEE: In Mr. Wirt's paper no mention is made of the protection of underground cables by means of static dischargers. The protection referred to being from static accumulations on cables. It is a mooted question whether these static dischargers are useful or not; some engineers are of the

opinion that this kind of apparatus produces more trouble than it prevents.

PETER JUNKERSFELD: For several years we have believed that under our conditions in Chicago static dischargers are, as Mr. Woodmansee intimates, liable to be more troublesome than useful; for this reason we have never installed them. Formerly the pressure was 4500 volts, but during the last two years it has been 9000 volts on our transmission system.

G. N. EASTMAN: The Edison Company is operating a grounded system and the static arresters would have no effect on the system except in case of certain current effects; in that case the energy which the static arresters would be capable of taking care of would be so small that their value would be questionable.

F. WOODMANSEE: Are they not in use on the Manhattan system? Perhaps some one from New York could tell us how they are operating. In the West there are two places where they have been in service only a short time—in Kansas City and Minneapolis. There is some difference of opinion as to whether they are of any value, or whether they are really introducing a number of weak points in the system which would have more serious effects than the static pressure.

PETER JUNKERSFELD: The New York Edison Company, it seems, does not use static dischargers on their 6600-volt, 25-cycle system which is a higher pressure than our old 4500-volt transmission, nor do they ground the neutral. In Chicago, since raising the pressure to 9000 volts, we have grounded the neutral.

H. B. ALVERSON: Referring to static dischargers, we have a system of between 40 and 50 miles of 11 000-volt cables and have no static dischargers. In about eight years' experience there have been but two instances where static dischargers might have been a possible benefit; that is, more than one cable giving out at the same time for the same cause.

CHARLES F SCOTT: Mr. Buck, of the Niagara Power Company, has said that he did not use static dischargers on the Niagara system and did not think it worth while; that he thought best to leave out as many of the safety devices as possible, as a safety device was apt to give more trouble than it prevented.

G. R. RADLEY: In Milwaukee static dischargers are used because the ozone had apparently formed an acid at certain places in the rubber cable, and at the hard-rubber bushings in several switches. Since installing them this effect has not been noticed, but since the neutral of the generators was grounded about the same time it may not be fair to give the credit entirely to the dischargers.

G. N. EASTMAN: On a system which is operated without a ground static arresters may be of some value. In one case with which the speaker is familiar, five miles of rubber-insulated, lead-covered cable was used, and many cases of trouble occurred. Lightning-arresters were installed and no benefit was noticed, but when the neutral was grounded the trouble disappeared.

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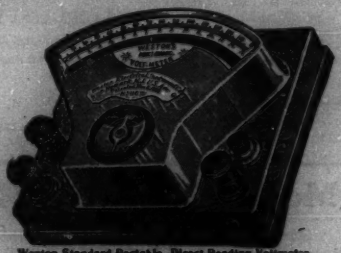

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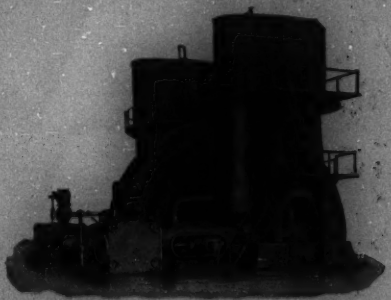

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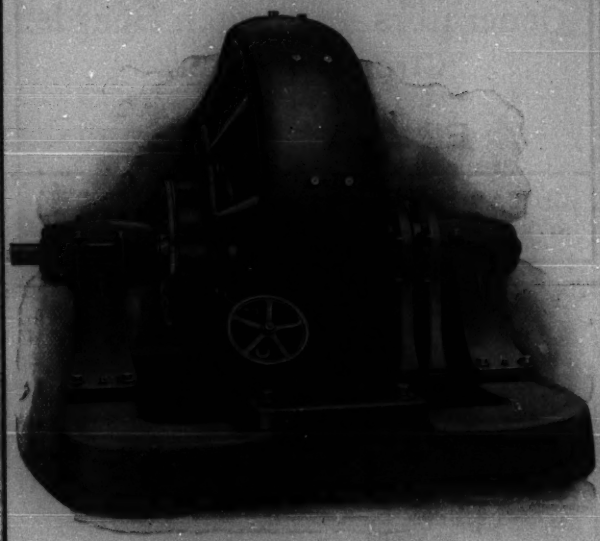

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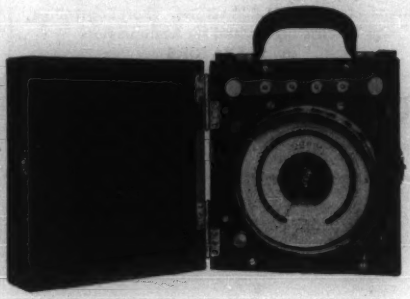

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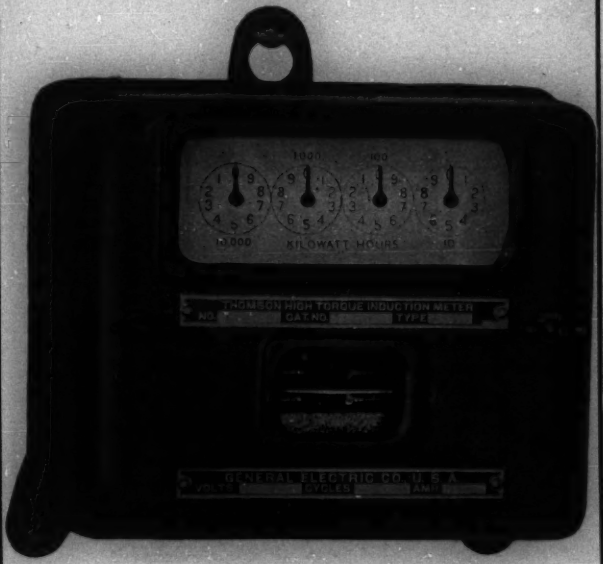

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